Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with Planned Exploration Drilling Activities During 2015 Chukchi Sea, Alaska

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ATTACHMENTS

List of Symbols, Acronyms and Abbreviations

~	approximate
°	Degrees
§	Section
4MP	Marine Mammal Monitoring and Mitigation Plan
AEWC	Alaska Eskimo Whaling Commission
AHD	acoustic harassment devices
ASAMM	Aerial Surveys of Arctic Marine Mammals Project
ATOC	Acoustic Thermometry of Ocean Climate
bbl.	barrel(s)
BCB	Bering-Chukchi-Beaufort stock (bowhead whales)
BO	Biological Opinion
BOEM	U.S. Bureau of Ocean Energy Management
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CHAOZ	Chukchi Acoustic, Oceanographic, and Zooplankton
CI	Confidence Interval
cm^3	cubic centimeters
Com Center	Communication and Call Center
COMIDA	Chukchi Sea Offshore Monitoring in Drilling Area
CSESP	Chukchi Sea Environmental Studies Program
DIMP	Drilling Ice Management Plan
Discoverer	*Noble Discoverer*
dB re 1µPa	decibels referenced 1 microPascal
DP	Dynamic Positioning
DPS	distinct population segment
EP	Chukchi Sea Exploration Plan, Revision 2
ESA	Endangered Species Act
Exploration Drilling program	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska
ft.	foot/feet
GP	General Permit
hr.	hour(s)
IHA	Incidental Harassment Authorization
$in.^3$	cubic inch(es)

Hz	hertz
IUCN	International Union for the Conservation of Nature
km	kilometer(s)
km^2	square kilometer(s)
km/hr.	kilometers per hour
LBCHU	Ledyard Bay Critical Habitat Unit
LC_{50}	Lethal Concentration 50 percent
m	meter(s)
mi^2	square miles
mi	statute mile(s)
min	minute(s)
MLC	mudline cellar
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MONM	Marine Operations Noise Model (JASCO)
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
OCS	Outer Continental Shelf
OSR	Oil Spill Response
OSRV	Oil Spill Response Vessel
OST	Oil Storage Tanker
OSV	Offshore Supply Vessel
POC	Plan of Cooperation
Polar Pioneer	Mobile Offshore Drilling Unit (MODU) *Transocean Polar Pioneer*
psi	pounds per square inch
PSO	Protected Species Observer
PTD	Proposed Total Depth
PTS	Permanent Threshold Shift
RL	Received Level
rms	root mean square
SAR	Search and Rescue

SEL	Sound Exposure Level
Shell	Shell Gulf of Mexico Inc.
SIWAC	Shell Ice and Weather Advisory Center
SSC	Sound Source Characterization
TTS	Temporary Threshold Shift
U.S.	United States
USFWS	United States Fish and Wildlife Service
VSI	Vertical Seismic Imager
VSP	Vertical Seismic Profile
yd	yard
yd^3	cubic yard
ZVSP	Zero-Offset Vertical Seismic Profile

EXECUTIVE SUMMARY

As described herein, during the 2015 exploration drilling season, Shell Gulf of Mexico Inc. (Shell) may drill at up to four exploration drill sites on the Chukchi Sea Outer Continental Shelf (OCS) leases acquired from the United States (U.S.) Department of Interior, Bureau of Ocean Energy Management (BOEM). The exploration drilling planned for the 2015 season is a continuation of the Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Exploration Drilling Program) that began in 2012, and resulted in the completion of a partial well at the location known as Burger A. Exploration drilling will be done pursuant to Shell's Chukchi Sea Exploration Plan, Revision 2 (EP). Shell plans to use two drilling units, the drillship *Noble Discoverer (Discoverer)* and semi-submersible *Transocean Polar Pioneer (Polar Pioneer)* to drill at up to four locations on the Burger Prospect. Both drilling units will be attended to by support vessels for the purposes of ice management, anchor handling, oil spill response (OSR), refueling, support to drilling units, and resupply. The drilling units will be accompanied by an expanded number of support vessels, aircraft, and oil spill response vessels (OSRV) greater than the number deployed during the 2012 drilling season.

The *Discoverer* and *Polar Pioneer* are industry standard drilling units which will execute drilling in all manners similar to that routinely conducted in the Beaufort and Chukchi Seas since the 1980s. During exploration drilling activities, the drilling units will emit near continuous non-pulse sounds that ensonify only very limited areas of the ocean bottom and intervening water column. Within the timeframe of exploration drilling activities, Shell may also conduct a particular type of short-duration Vertical Seismic Profile (VSP) survey known as a zero-offset VSP (ZVSP) at each drill site. The ZVSPs emit pulse sounds that also ensonify very limited areas of the ocean bottom and intervening water column for approximately 10-14 hours. Typically, a single ZVSP survey will be performed when drilling has reached a proposed total depth (PTD) or final depth. ZVSP was not conducted in 2012 since drilling at the Burger A drill site was stopped at the bottom of the top hole section.

Since the early 1990s, the National Marine Fisheries Service (NMFS) has issued Incidental Harassment Authorizations (IHAs) to industry for the non-lethal taking of small numbers of marine mammals related to the non-pulse, continuous sounds generated by offshore exploration drilling and impulse sounds generated during seismic surveys. Shell requests an IHA pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a) (5) to allow non-lethal takes of whales and seals incidental to the 2015 exploration drilling season, including ZVSP surveys, and other related activities.

As in 2012, Shell has calculated the estimated aggregate exposures of marine mammals from the low-level continuous sound generated during exploration drilling activities, icebreaking as a result of ice management, and impulse sound generated during short-duration ZVSP surveys likely to occur at or near the end of drilling each well. In addition to sounds generated during exploration drilling, icebreaking, and ZVSP, new sound categories have been added to analyze acoustic impacts related to the 2015 exploration program: sound generated while constructing the mudline cellar (MLC), sound due to anchor handling while mooring a drilling unit at a drill site, and sound made by support vessels while on dynamic positioning (DP) when tending to the drilling units at drill sites. Inclusion of the new sound categories in the pre-season aggregate exposure estimates, along with the addition of a second drilling unit and associated support vessels increases the total number of marine mammal exposures as estimated in 2012.

The estimates shown in Table ES-1 reflect the results of a multistep process for calculating the exposure of animals to Level B thresholds. The first of these steps estimates the number of marine mammals that may be present in areas exposed to Level B thresholds for a range of activity scenarios and sums them together. Estimates from this method do not account for animal avoidance, movements into or out of exposed areas, or new animals moving through (i.e., turnover) that might occur during the course of each season. The second step for estimating exposures produces conservative estimates and takes into account assumptions of turnover rates of animals in the project area and avoidance rates. For all species except bowhead whales, it is assumed that there is 100% replacement of individual marine mammals with zero avoidance every 24 hours. This is likely to overestimate exposure in most cases, resulting in over estimation of the number of individuals that would actually be exposed to Level B thresholds. For bowhead whales, we relied on the best available data to support our assumption that whales may avoid the action area by up to 50% and also assumed a 24 hour turnover rate (Table ES-1). Additional details relating to these precautionary methods are discussed in sections 6 and 7 of this application.

As detailed herein, exposures that may result from any of the proposed activities would be temporary and would not be biologically significant to marine mammal populations. Impacts from these sounds to whales and seals would be temporary and could result in, at the most, short-term displacement of seals and whales from within ensonified zones produced by such sound sources.

Many marine mammals, particularly pinnipeds, exposed to continuous sound levels near 120 decibels [reference sound pressure of 1 microPascal (dB re 1 μPa) root mean square (rms)] would not react, and exposure to this sound level should not be considered as "takes by harassment" in such cases. Even for marine mammal species that may change their behavior or alter their migration route to divert around an activity, those changes are likely to be within the normal range of activities for the animals and may not rise to the level of a "take" based on prior decisions by NMFS (2012d).

> "*Although it is possible that marine mammals could react to any sound levels detectable above the ambient noise level within the animals' respective frequency response range, this does not mean that such a reaction would be considered a take. According to experts on marine mammal behavior, whether a particular stressor could potentially disrupt the migration, breathing, nursing, breeding, feeding, or sheltering, etc., of a marine mammal, i.e., whether it would result in a take, is complex and context specific, and it depends on several variables in addition to the received level of the sound by the animals." 77 Fed. Reg. at 27290.*

Table ES-1 takes into account factors of avoidance and turn-over rates where supported by best available data and represent Level B exposures which result in negligible effects on the species or stocks of marine mammals exposed. In regard to the subsistence harvest of marine mammals, Shell also concludes that any harassment that may occur will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses. See Section 8.

Shell relied on guidance in 50 Code of Federal Regulations (CFR) Section § 216.104, Submission of Requests, to prepare its request for this IHA:

> (a) In order for the NMFS to consider authorizing the taking by U.S. citizens of small numbers of marine mammals incidental to a specified activity (other than commercial fishing), or to make a finding that incidental take is unlikely to occur, a written request must be submitted to the Assistant Administrator. All requests must include the following information for their activity:

The organization of this request for an IHA follows the organization of 50 CFR § 216.104 (a) (1)-(14).

Table ES-1 Number of Potential Exposures of Marine Mammals to Received Sound Levels in the Water of >120 dB re 1 µPa rms Generated by Exploration Drilling and >160 dB re 1 µPa rms Generated by ZVSPs during 2015 Exploration Drilling.

Species	Abundance Estimate*	Number of Individuals Potentially Exposed to Continuous Sounds ≥120 dB re 1 µPa (rms) or Pulsed Sounds ≥160 dB e 1 µPa (rms)**	Percent of Estimated Population
Odontocetes			
Monodontidae			
Beluga	42,968[1]	974	2.3
Narwhal	NA[2]	1	0.0
Delphinidae			
Killer whale	2,084[3]	14	0.7
Phocoenidae			
Harbor porpoise	48,215[4]	294	0.6
Mysticetes			
Bowhead whale	19,534[5]	2,582	13.2
Fin whale	1,652[6]	14	0.8
Gray whale	19,126[7]	2,581	13.5
Humpback whale	20,800[8]	14	0.1
Minke whale	810[9]	41	5.1
Pinnipeds			
Bearded seal	155,000[10]	1,722	1.1
Ribbon seal	49,000[11]	96	0.2
Ringed seal	300,000[12]	50,433	16.8
Spotted seal	141,479[13]	1,007	0.7

*With the exception of bowhead and gray whale, reliable population estimates do not exist and these percentages should be interpreted with care. Additionally, the best available abundance estimates often include only a portion of the known distribution and range for a given population, which results in overestimation of the percent of individuals exposed within those populations.

**Assumptions for each species included 100% daily turnover and no avoidance of ensonified areas with the exception of bowhead whale, for which 100% daily turnover and 50% avoidance of ensonified areas were assumed.

[1]Allen and Angliss 2014, sum of minimum population estimates for Eastern Chukchi and Beaufort Sea Stocks

[2]Allend and Angliss, 2014; Narwhals in Alaska are extremely rare, no reliable abundance estimate for this species

[3]Allen and Angliss 2014, minimum population estimate for Eastern North Pacific Alaska Resident Stock

[4]Allen and Angliss 2014, considered conservative estimate for Bering Sea Stock

[5]Givens et al. 2013, projected 2015 population using 2011 census of Bering-Chukchi-Beaufort Stock of 16,892 with annual growth rate of 3.7%

[6]Allen and Angliss 2014, conservative estimate of Northeast Pacific Stock from Zerbini et al. 2006 surveys of Western Alaska conducted during 2001-2003

[7]Laake et al. 2009, estimate for entire North Pacific population

[8]Allen and Angliss 2014, estimate for entire North Pacific population

[9]Allen and Angliss 2014, conservative estimate of Alaska Stock from Moore et al. 2002 surveys in the central-eastern and southeastern Bering Sea

[10]Allen and Angliss 2014, estimate from Cameron et al. 2010 sum of bearded seals in Bering and Chukchi Seas

[11]Allen and Angliss 2014, based on recent provisional estimate by Boveng et al. 2008

[12]Allen and Angliss 2014, conservative estimate from Kelly et al. 2010 for Chukchi and Beaufort Seas

[13]Allen and Angliss 2014, conservative estimate from Ver Hoef et al. *in review* for areas surveyed in eastern and central Bering Sea in 2007

1. DESCRIPTION OF SPECIFIED ACTIVITY

The specific activities that may result in incidental taking of marine mammals pursuant to the requested IHA are limited to Shell's exploration drilling program and related activities and we expect the disturbance to be primarily acoustic in nature. Activities include exploration drilling, MLC construction, anchor handling while mooring a drilling unit at a drill site, vessels on DP when tending to a drilling unit, ice management, and ZVSP surveys.[1]

Exploration Drilling

In 2015, Shell plans to continue its exploration drilling program on BOEM Alaska OCS leases at drill sites greater than 64 miles (mi) (103 kilometers [km]) from the Chukchi Sea coast during the 2015 drilling season (Figure 1-1). Shell plans to conduct exploration drilling activities at up to four drill sites at the Burger Prospect (Table 2-1) utilizing two drilling units, the drillship *Discoverer* and the semi-submersible *Polar Pioneer*.

During 2012, Shell drilled a partial well at the Burger A drill site. Burger A did not reach a depth at which a ZVSP survey would be conducted, consequently one was not performed.

A MLC will be constructed at each drill site. The MLCs will be constructed in the seafloor using either a large diameter bit operated by hydraulic motors and suspended from the *Discoverer* or *Polar Pioneer*

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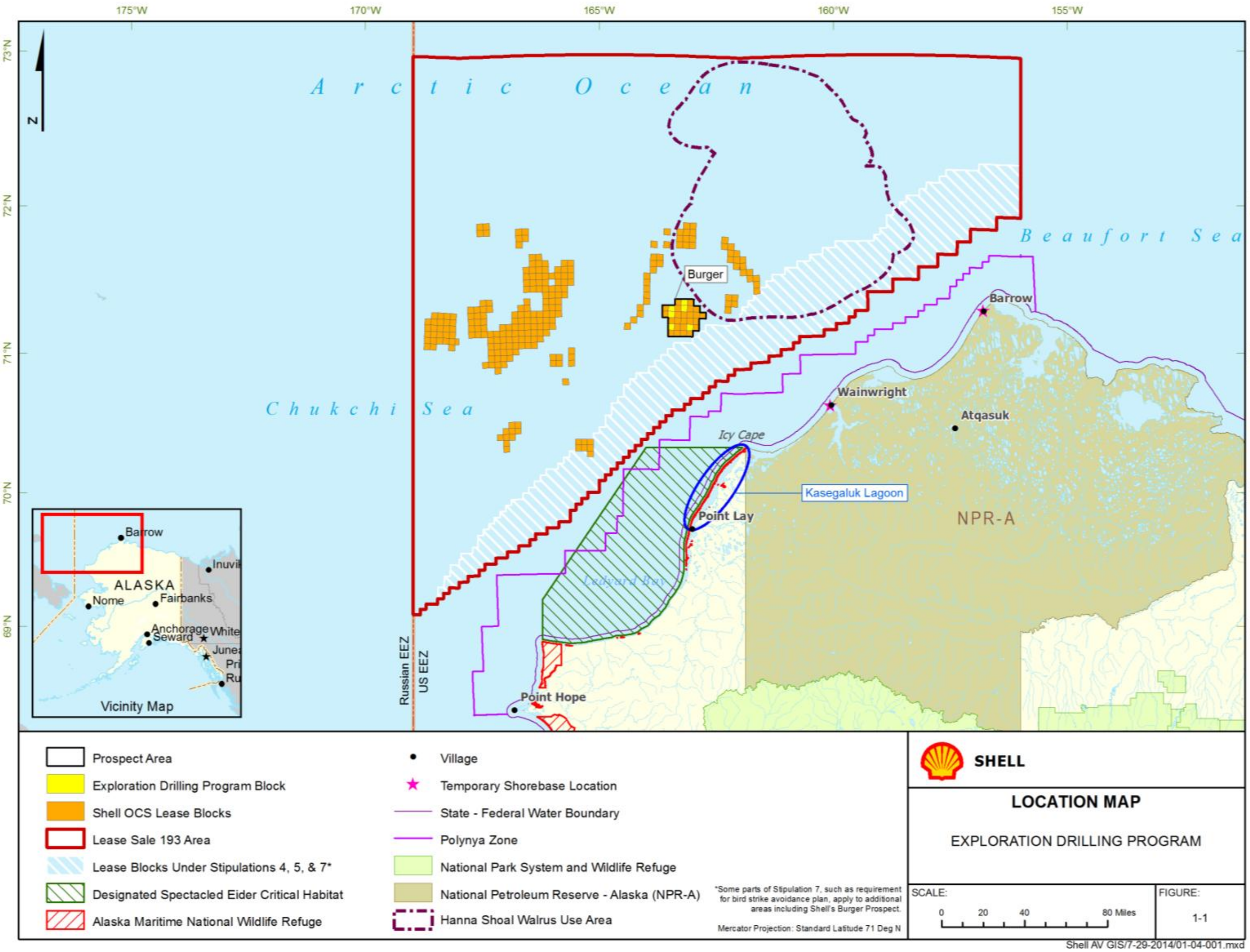
[1] In the past, questions have been raised during the MMPA incidental take authorization process about the possibility of a large spill or very large oil spill (VLOS) resulting from Shell's Arctic exploration drilling program. *See* 77 Fed. Reg. 27322, 27338 (May 9, 2012). It is Shell's position that a hypothetical oil spill of this magnitude should not be included in the description of the "specified activity" as defined under the MMPA's implementing regulations because it is a highly unlikely event and because such impacts would not be substantially similar to the expected impacts (i.e., acoustic disturbance). NMFS endorsed this position when it authorized the take of marine mammals incidental to Shell's 2012 Chukchi Sea exploration drilling program. *See id.* at 27341-42; *see also,* NMFS, 2012e. Regardless, Shell has evaluated the probability of a large spill and VLOS and the associated environmental impacts in its draft 2015 Exploration Plan and EIA, and also included a description of the measures it intends to employ to help prevent an oil spill from occurring. *See* Shell, 2014. The issue has also been considered extensively in past environmental planning documents, which we would encourage NMFS to review. *See, e.g.,* MMS 2003, MMS 2007, BOEMRE 2011, BOEM 2011a, NMFS 2013b.

Figure 1-1 Exploration Drilling Program Location Map



Support Vessels

During this exploration drilling program, the *Discoverer and Polar Pioneer* will be supported by the types of vessels listed in Table 1-1. These drilling units would be accompanied by an expanded number of support vessels and oil spill response vessels than were deployed by Shell during 2012 exploration drilling in the Chukchi Sea.

Two ice management vessels will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. Ice management and ice scouting is expected to occur at distances of 20 mi (32 km) and 30 mi (48 km) respectively from the drilling units. However, these vessels may have to expand beyond these ranges depending on ice conditions.

Up to three anchor handlers will support the drilling units. These vessels will enter and exit the Chukchi Sea with or ahead of the drilling units, and will generally remain in the vicinity of the drilling units during the drilling season. When the vessels are not anchor handling, they will be available to provide other general support. Two of the three anchor handlers may be used to perform secondary ice management tasks if needed.

The planned exploration drilling activities will use three offshore supply vessels (OSV) for resupply of the drilling units and support vessels. Drilling materials, food, fuel, and other supplies will be picked up in Dutch Harbor (with possible minor resupply coming out of Kotzebue) and transported to the drilling units and support vessels.

Shell plans to use up to two science vessels; one for each drilling unit, from which sampling of drilling discharges would be conducted. The science vessel specifications are based on larger OSVs, but smaller vessels may be used.

Two tugs will tow the *Polar Pioneer* from Dutch Harbor to the Burger Prospect. After the *Polar Pioneer* is moored, the tugs will remain in the vicinity of the drilling units to help move either drilling unit in the event they need to be moved off of a drilling site due to ice or any other event. The *Discoverer* is self-propelled.

Table 1-1 Chukchi Sea Exploration Drilling Program – Proposed Vessel Types

Specification	Ice Management Vessel (x2)[1]	Anchor Handler (x3)[2]	OSV (x3)[3]	Drilling Discharge Monitoring Science Vessel (x2)[4]	Shallow Water Vessel (x2)[5]	Support Tugs (x2)[6]	Resupply Tug and Barges (x2)[7]	
							Tug	Barge
Length	380 ft. (116 m)	361 ft. (110.1 m)	300 ft. (91.5 m)	300 ft. (91.5 m)	134 ft. (40.8 m)	146 ft. (44.5 m)	150 ft. (45.7 m)	400 ft. (122 m)
Width	85 ft. (26 m)	80 ft. (24.4 m)	60 ft. (18.3 m)	60 ft. (18.3 m)	32 ft. (9.7 m)	46 ft. (14 m)	40 ft. (12.2 m)	99.5 ft. (30.3m)
Draft	27 ft. (8.4 m)	28 ft. (8.5 m)	15.9 ft. (4.9 m)	15.9 ft. (4.9 m)	6 ft. (1.8 m)	21 ft. (6.4 m)	19.5 ft. (5.9 m)	25 ft. (7.6 m)
Accommodations	82	64	50	50	22	13	11	--
Maximum Speed	16 knots (30 km/hr.)	15 knots (28 km/hr.)	13 knots (24 km/hr.)	13 knots (24 km/hr.)	10 knots (18 km/hr.)	16 knots (30 km/hr.)	12 knots (22 km/hr.)	--
Available Fuel Storage	14,192 bbl. (2,256m^3)	11,318 bbl. (1,799 m^3)	5,786 bbl. (920 m^3)	5,786 bbl. (920 m^3)	667 bbl. (106 m^3)	5,585 bbl. (888 m^3)	4,800 bbl. (774 m^3)	--

[1] *Based on Nordica or similar vessel*
[2] Based on *Aiviq* or similar vessel
[3] Based on the *Harvey Champion* or similar vessel
[4] Based on the *Harvey Champion* or similar vessel
[5] Based on the *Arctic Seal; Vessels will be located in Kotzebue Sound and not transiting to a drill site*
[6] Based on the tug *Ocean Wave; Tugs will be located in Kotzebue Sound and not transiting to a drill site*
[7] Based on the *Lauren Foss* (tug) and *Tuuq* (barge)

Oil Spill Response Vessels

The OSR vessel types supporting the exploration drilling program are listed in Table 1.2.

One dedicated OSR barge and on-site OSRV will be staged in the vicinity of the drilling unit(s) when drilling into potential liquid hydrocarbon bearing zones. This will enable the OSRV to respond to a spill and provide containment, recovery, and storage for the initial response period in the unlikely event of a well control incident.

The OSR barge, associated tug, and OSRV possess sufficient storage capacity to provide containment, recovery, and storage for the initial response period. Shell plans to use two oil storage tankers (OST). An OST will be staged at the Burger Prospect. The OST will hold fuel for Shell’s drilling units, support vessels, and have space for storage of recovered liquids in the unlikely event of a well control incident. A second OST will be stationed outside the Chukchi Sea lease sale planning area and will be sited such that it will be able to respond to a well control event before the first tanker reaches its recovered liquid capacity.

The tug and barge will be used for nearshore OSR. The nearshore tug and barge will be moored near Goodhope Bay, Kotzebue Sound. The nearshore tug and barge will also carry response equipment, including one 47 ft. (14 m) skimming vessel, 34 ft. (10 m) workboats, mini-barges, boom and duplex skimming units for nearshore recovery and possibly support nearshore protection. The nearshore tug and barge will also carry designated response personnel and will mobilize to recovery areas, deploy equipment and begin response operations.

Table 1-2 Chukchi Sea Exploration Drilling Program – Proposed Oil Spill Response Vessel Types

Specification	OSR Vessel [1,2]	Offshore OSR [1,3]		Nearshore OSR[1,4, 9]		OST [1,5]	OST [1,6, 9]	Containment Barge [1,7, 9]	
		Tug	Barge	Tug	Barge			Tug	Barge
Length	301 ft. (91.9 m)	126 ft. (38.4 m)	333 ft. (101.5 m)	90 ft. (27.4 m)	205 ft. (62.5 m)	748 ft. (228 m)	813 ft. (248 m)	150 ft. (45.7 m)	316.5 ft. (96.5 m)
Width	60 ft. (18.3 m)	34 ft. (10.4 m)	76 ft. (23.1 m)	32 ft. (9.8 m)	90 ft. (27.4 m)	105 ft. (32 m)	141 ft. (48 m)	40 ft. (12.2 m)	105 ft. (32 m)
Draft	19 ft. (5.8 m)	17 ft. (5.2 m)	22 ft. (6.7 m)	10 ft. (3 m)	15 ft. (4.6 m)	66 ft. (20 m)	69 ft. (21 m)	19.5 ft. (5.9 m)	12.5 ft. (3.8 m)
Accommodations	41	15	--	8	25	25	25	11	72
Maximum Speed	16 knots (30 km/hr.)	12 knots (22 km/hr.)	--	12 knots (22 km/hr.)	--	15 knots (28 km/hr.)	15 knots (28 km/hr.)	10 knots (19 km/hr.)	--
Available Fuel Storage	7,692 bbl. (1,223 m^3)	1,786 bbl. (284 m^3)	390 bbl. (62 m^3)	1,286 bbl. (204.5 $m^{3)}$	--	16,121 bbl. (2,563m^3)	20,241 bbl. (3,218 m^3)	4,800 bbl. (763 m^3)	6,630 bbl. (1,054 m^3)
Available Liquid Storage	12,245 bbl. (1,947 m^3)	--	76,900 bbl. (12,226 m^3)	--	17,000 bbl. (5,183 m^3)	106,000 bbl[8] (16,852 m^3)	670,000bbl (106,518 m^3)	--	--
Workboats	(3) 34 ft. work boats		--	--	(1) skim boat 47 ft. (14 m) (3) work boats 34 ft. (10 m) (4) mini-barges--	--	--	--	--

[1] Or similar vessel
[2] Based on the *Nanuq*
[3] Based on the tug *Guardsman* (tug) and *Klamath* (barge)
[4] based on the *Point Oliktok* (tug) and Endeavor (barge)
[5] Based on a Panamax type tanker
[6] Based on an Aframax type tanker
[7] Based on the *Corbin Foss* (tug), *Arctic Challenger* (barge) and the *Ross Chouest* (anchor handler)
[8] Total available storage is 350,000 bbl.; however, 244,000 bbl. of ULSD or a fuel with equal or lower sulfur content (used to refuel the drilling units and support vessels) will take up storage space, leaving 106,000 bbl. for recovered liquids. Storage space for recovered liquids will increase as fuel is dispensed for refueling.
[9] These vessels will be moored in Kotzebue Sound; however the OST may be moored elsewhere. The remaining vessels will be stationed in the vicinity of the drilling units

Aircraft

Offshore operations will be serviced by up to three helicopters operated out of an onshore support base in Barrow. The helicopters are not yet contracted. Sikorsky S-92s (or similar) will be used to transport crews between the onshore support base, the drilling units and support vessels with helidecks. The helicopters will also be used to haul small amounts of food, materials, equipment, samples and waste between vessels and the shorebase. Approximately 40 Barrow to Burger Prospect round trip flights will occur each week to support the additional crew change necessities for an additional drilling unit, support vessels, required sampling and analytical requirements under the National Pollutant Discharge Elimination System (NPDES) exploration facilities General Permit (GP).

The route chosen will depend on weather conditions and whether subsistence users are active on land or at sea. These routes may be modified depending on weather and subsistence uses.

Shell will also have a dedicated helicopter for Search and Rescue (SAR). The SAR helicopter is expected to be a Sikorsky S-92 (or similar). This aircraft will stay grounded at the Barrow shorebase location except during training drills, emergencies, and other non-routine events. The SAR helicopter and crew plan training flights for approximately 40 hr. /month.

A fixed wing propeller or turboprop aircraft, such as the Saab 340-B, Beechcraft 1900, or De Havilland Dash 8, will be used to transport crews, materials, and equipment between Wainwright and hub airports such as Barrow or Fairbanks. It is anticipated that there will be one round trip flight every three weeks.

A fixed wing aircraft, Gulfstream Aero-Commander (or similar), will be used for photographic surveys of marine mammals. These flights will take place daily depending on weather conditions. Protected Species Observer (PSO) flight paths are located in the Marine Mammal Monitoring and Mitigation Plan (4MP) (Attachment B).

An additional Gulfstream Aero Commander may be used to provide ice reconnaissance flights to monitor ice conditions around the Burger Prospect. Typically, the flights will focus on the ice conditions within 50 mi (80 km) of the drill sites, but more extensive ice reconnaissance may occur beyond 50 mi (80 km). These flights will occur at an altitude of approximately 3,000 ft. (915 m).

Table 1-3 Trip Information for Support Aircraft

Aircraft Type [1] / Purpose	Trip Frequency or Duration
(1) Saab 340 B, Beechcraft 1900, Dash 8, or similar fixed-wing aircraft for transport from shorebase to regional jet service in Deadhorse or Barrow	1 trip every 3 weeks between Wainwright and Barrow or Anchorage
(3) S-92, EC225, or similar helicopters for crew rotation & groceries/supply	Approximately 40 round trips/week between shorebase & prospect – approx. 3 hr./trip
(1) S-61, S-92, EC225, or similar helicopter for search-and-rescue	Stationed in Barrow – 40 hr./month for proficiency training & trips made in emergency
(2) Gulfstream 690 Aero Commander (or similar)	Photographic marine mammal surveys and ice reconnaissance; both to occur daily when possible

[1] Similar model of aircraft may be contracted for these purposes

Vertical Seismic Profile

Shell may conduct a geophysical VSP survey at each drill site where a well is drilled in 2015. During VSP surveys, an airgun array is deployed at a location near or adjacent to the drilling units, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the VSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell will be conducting a particular form of VSP referred to as a ZVSP, in which the sound source is maintained at a constant location near the wellbore (Figure 1-2). Shell may use one of two typical sound sources: 1) a three-airgun array consisting of three150 cubic inches (in^3) (2,458 cubic centimeters [cm^3]) airguns, or 2) a two-airgun array consisting of two, 250 in^3 (4,097 cm^3) airguns. Specifications for the maximum volume of the array are provided in Table 1.4. An airgun array is depicted within its frame or sled in the photograph below. Typical receivers would consist of a standard wireline four-level Vertical Seismic Imager (VSI) tool, which has four receivers 50 ft. (15.2 m) apart.

Photograph of the 3-airgun array in sled

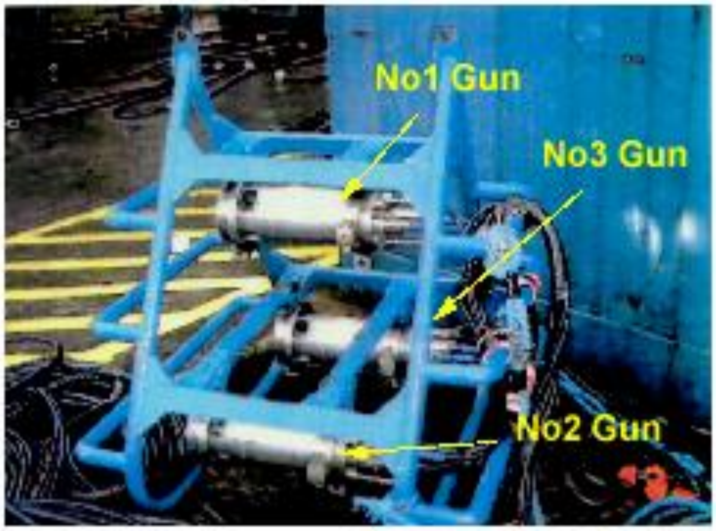


Figure 1-2 Schematic of ZVSP

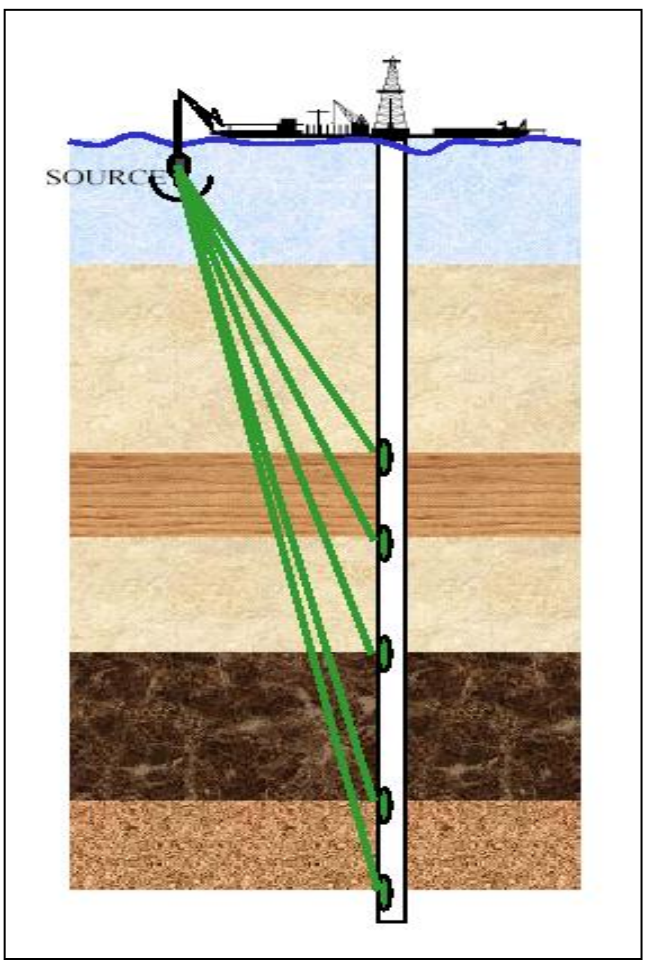


Table 1-4 Sound source (airgun array) specifications for ZVSP surveys in the Chukchi Sea in 2015

Source Type	No. Sources	Max. Total Chamber Size	Pressure	Source Depth	Zero-Peak Sound Pressure Level
Sleeve Array	(3) airguns (3) 150 in^3	450 in^3 7,374 cm^3	3,000 psi 207 bar	23 ft. (7.0 m)	241 dB rms re1µPa @1m
Sleeve Array	(2) airguns (2) 250 in^3	500 in^3 8,194 cm^3	3,000 psi 207 bar	23 ft. (7.0 m)	239 dB rms re1µPa @1m

dB re 1 µPa – decibels referenced 1 microPascal
dB – decibel

A ZVSP survey is normally conducted at each well after total depth is reached, but may be conducted at a shallower depth. For each survey, Shell would deploy the sound source (airgun array) over the side of the *Discoverer* or *Polar Pioneer* with a crane, the sound source will be 50-200 ft. (15-61 m) from the wellhead depending on crane location, and reach a depth of approximately 10-23 ft. (3-7 m) below the water surface. The VSI along with its four receivers will be temporarily anchored in the wellbore at depth. The sound source will be pressured up to 3,000 pounds per square inch (psi) (207 bar), and activated 5-7 times at approximately 20 second intervals. The VSI will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire wellbore is surveyed. The interval between anchor points for the VSI is usually 200-300 ft. (61-91 m). A normal ZVSP survey for each well is conducted over a period of about 10-14 hours depending on the depth of the well and the number of anchoring points.

Ice Management and Forecasting

Shell recognizes the exploration drilling program is located in an area that is characterized by active sea ice movement, ice scouring, and storm surges. In anticipation of potential ice hazards that may be encountered, Shell will implement a Drilling Ice Management Plan (DIMP) (Attachment A) to ensure real-time ice and weather forecasting that will identify conditions that could put operations at risk, allowing Shell to modify its activities accordingly. Shell's DIMP relies heavily on the observations and experience of its Ice Specialists and Ice Advisors, a group of seasoned Arctic mariners whose sole duty is to provide critical information and provide advice drilling unit supervisors and the drilling unit master about any and all ice-related threats. These observers and advisors will be stationed on the drilling units, the ice management vessels and the anchor handlers. The DIMP also contains ice threat classification levels depending on the time available to suspend drilling operations, secure the well and escape from advancing hazardous ice. Real-time ice and weather forecasting will be available to operations personnel for planning purposes and as a tool to alert the fleet of impending hazardous ice and weather conditions. Ice and weather forecasting is provided by Shell's Ice and Weather Advisory Center (SIWAC). This center is continuously manned by experienced personnel, who rely on a number of data sources for ice forecasting and tracking, including:

- Radarsat Data Synthetic Aperture Radar - provides all-weather imagery of ice conditions with very high resolution;
- Moderate Resolution Imaging Spectroradiometer (MODIS) - a satellite providing lower resolution visual and near infrared imagery;
- Other publically available remote sensing satellite data such as Visible Infrared Imaging Radiometer Suite, Oceansat-2 Scatterometer, and Advanced Very High Resolution Radiometer;
- Aerial reconnaissance - Opportunistic photographic and observational feedback from rotary or fixed wing aircraft;

- Reports from Ice Specialists on the ice management vessel and anchor handler and from the Ice Observer on the drilling units;
- Incidental ice data provided by commercial ships transiting the area; and
- Information from the National Oceanic and Atmospheric Administration (NOAA) ice centers and the University of Colorado

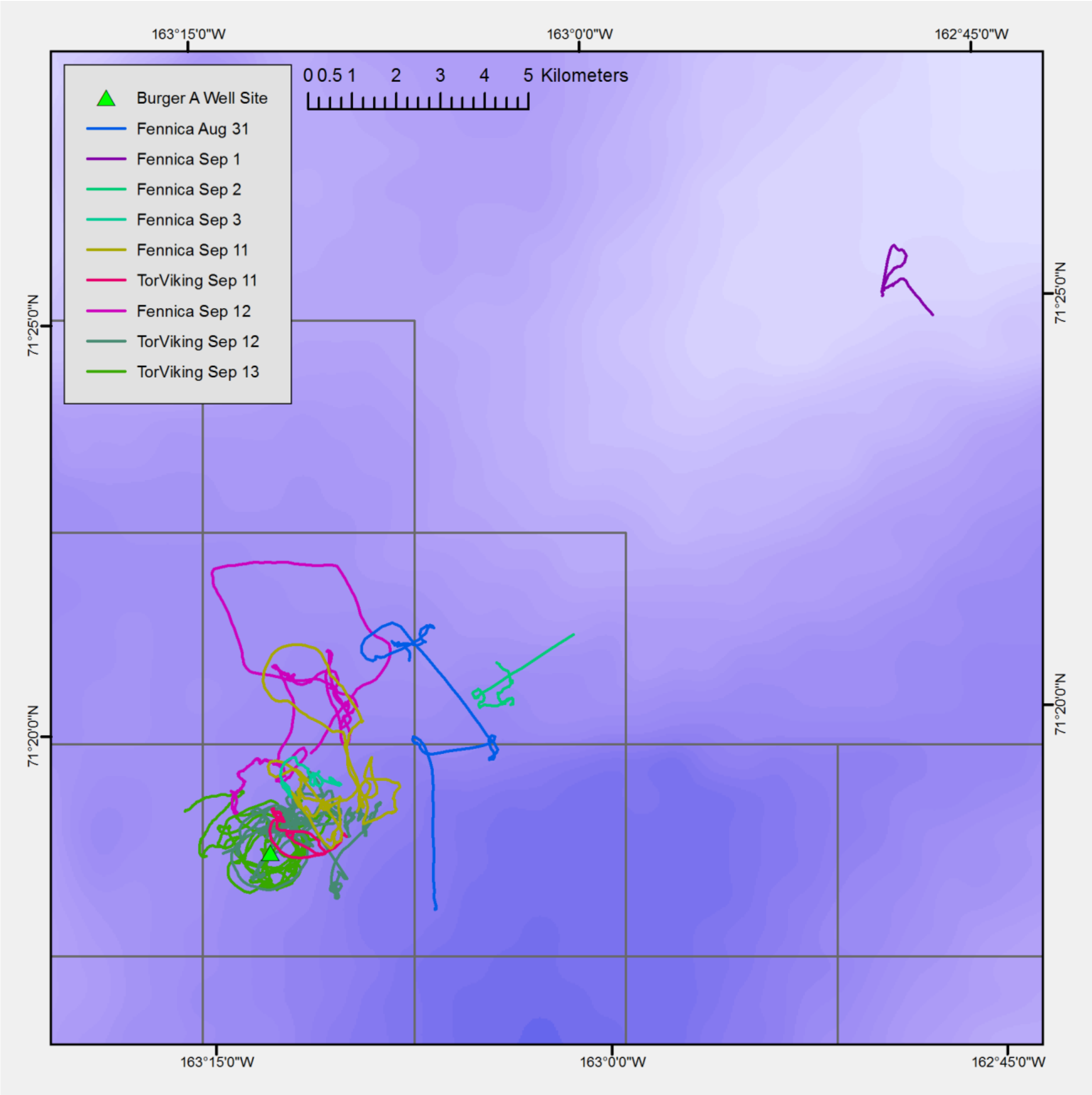
Shell's ice management fleet will consist of four vessels: two ice management vessels and two anchor handler/icebreakers. Ice management that is necessary for safe operations during Shell's planned exploration drilling program will occur far out in the OCS, remote from the vicinities of any routine marine vessel traffic in the Chukchi Sea, thereby resulting in no threat to public safety or services that occur near to shore. Shell vessels will also communicate movements and activities through the 2015 North Slope Communications Centers (Com Center). Management of ice will occur during the drilling season predominated by open water, thus it will not contribute to ice hazards, such as ridging, override, or pileup in an offshore or nearshore environment.

The ice-management/anchor handling vessels will manage the ice by deflecting any ice floes that could affect the *Discoverer* or the *Polar Pioneer* when they are drilling or anchor mooring buoys even if the drilling units are not anchored at a drill site. When managing ice, the ice management vessels will generally operate upwind of the drilling units, since the wind and currents contribute to the direction of ice movement. Ice reconnaissance or ice scouting forays may occur out to 48.3 km (30 mi) from the drilling units and are conducted by the ice management vessels into ice that may move into the vicinity of exploration drilling activities. This will provide the vessel and shore-based ice advisors with the information required to decide whether or not active ice management is necessary. The actual distances from the drilling units and the patterns of ice management (distances between vessels, and width of the swath in which ice management occurs) will be determined by the ice floe speed, size, thickness, and character, and wind forecast.

Ice floe frequency and intensity is unpredictable and could range from no ice to ice densities that exceed ice-management capabilities, in which case drilling activities might be stopped and the drilling units disconnected from their moorings and moved off site. The *Discoverer* was disconnected from its moorings once during the 2012 season to avoid a potential encounter with multi-year ice flows of sufficient size to halt activities. Advance scouting of ice primarily north and east of the Burger A well by the ice management vessels did not detect ice of sufficient size or thickness to warrant disconnecting the *Discoverer* from its moorings during the remainder of the 2012 season. If ice is present, ice management activities may be necessary in early July, at discrete intervals at other times during the season, and towards the end of operations in late October. However, data regarding historic ice patterns in the area of activities indicate that it will not be required throughout the planned 2015 drilling season.

Figure 1-3 depicts the vessel tracts of the *Fennica* and *Tor Viking* in the Chukchi Sea from August 31-to September 13, 2012, during which active ice management occurred in relation to the location of Burger A. Combined, these vessel tracts show the patterns of ice management by vessels and the duration of time necessary for active ice management in 2012. In total, seven days of active ice management by vessels occurred in support of Shell's exploration drilling program in the Chukchi Sea during the 2012 season.

Figure 1-3 Ice Management Vessel Movements during 2012 in the Chukchi Sea



When ice is present at a drill site, ice disturbance will be limited to the minimum amount needed to allow drilling to continue. First-year ice will be the type most likely to be encountered. The ice-management vessel will be tasked with managing the ice so that it flows easily around the drilling units and their anchor moorings without building up in front of either. This type of ice is managed by the ice-management vessel continually moving back and forth across the drift line, directly up drift of the drilling units and making turns at both ends, or in circular patterns. During ice-management, the vessel's propeller is rotating at approximately 15 to 20 percent of the vessel's propeller rotation capacity. Ice management occurs with slow movements of the vessel using lower power and therefore slower propeller rotation speed (*i.e.,* lower cavitation), allowing for fewer repositions of the vessel, and thereby reducing cavitation effects in the water. Occasionally, there may be multi-year ice features that would be managed at a much slower speed than that used to manage first-year ice.

As detailed in Shell's DIMP, in 2012 Shell's ice management vessels conducted ice management to protect moorings for the *Discoverer* after the drilling unit was moved off of the Burger A well. This work consisted of re-directing flows as necessary to avoid potential impact with mooring buoys, without the necessity to break up multi-year ice flowbergs. Actual breaking of ice may need to occur in the event that ice conditions in the immediate vicinity of activities create a safety hazard for the drilling unit, or its moorings. In such a circumstance, operations personnel will follow the guidelines established in the DIMP to evaluate ice conditions and make the formal designation of a hazardous ice alert condition, which would trigger the procedures that govern any actual icebreaking operations. Despite Shell's experience in 2012, historical data relative to ice conditions in the Chukchi Sea in the vicinity of Shell's planned 2015 activities, establishes that there is a low probability for the type of hazardous ice conditions that might necessitate icebreaking (e.g., records of the National Naval Ice Center archives; Shell/SIWAC). The probability, however, could be greater at the beginning and/or the end of the drilling season (early July or late October). For the purposes of evaluating possible impacts of the planned activities, Shell has assumed icebreaking activities for a limited period of time, and estimated incidental exposures of marine mammals from such activities.

Planned Mitigation

NMFS regulations require an operator to include a description of planned mitigation to achieve the least practicable adverse impact on affects species or stocks and a Plan of Cooperation (POC) or information that identifies the measures that have been taken and/or will be taken to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR §§ 216.104(a)(11) & (12). The drilling units and all support vessels and aircraft will operate in accordance with the provisions of Shell's 4MP and the POC Addendum prepared for the 2015 season (Attachments B&C). These documents describe the measures Shell intends to implement to mitigate the effects of Shell's planned exploration drilling program on affected marine mammal species or stocks and their habitat and to minimize any adverse effects on the availability of a species or stock for Arctic subsistence use.

The POC Addendum was prepared based upon Shell's experiences since the 1980s in the Alaska OCS and in consultation with potentially affected Chukchi Sea communities and marine mammal commissions. During meetings held in the fall of 2014, Shell focused on lessons learned from 2012, planned activities and presented mitigation measures for avoiding potential conflicts. Shell's POC Addendum addresses the issues of vessel transit, drilling, aerial support, and associated onsite vessel activities. The mitigation measures described in Section 12 are intended to minimize any adverse effects on the availability of marine mammals for subsistence use. Shell conducted additional POC meetings in Chukchi Sea villages in November 2013, January 2014, and July 2014. Shell has supplemented this IHA application with a POC addendum that includes these visits. Throughout 2014 and 2015 Shell anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

2. DATES AND DURATION, SPECIFIED GEOGRAPHIC REGION

Anticipated Duration of this Permit

Shell anticipates that the IHA issued by the NMFS for the planned Chukchi Sea exploration drilling program will be valid from the date of issuance through the conclusion of the 2015 drilling season. Exploration drilling activities in the Chukchi Sea will continue until on or about 31 October, while the unmooring of the drilling units and movement off-site of the drilling units and support vessels may continue into November. Transit entirely out of the Chukchi Sea by all vessels associated with exploration drilling may take well into the month of November due to ice, weather, and sea states.

Timing of Mobilization and Demobilization of the *Discoverer* and *Polar Pioneer*

The drilling units will move through the Bering Strait and into the Chukchi Sea on or after 1 July and then onto the Burger Prospect as soon as ice and weather conditions allow. Exploration drilling activities will continue until on or about 31 October, the drilling units and support vessels will exit the Chukchi Sea at the conclusion of each exploration drilling season. Transit entirely out of the Chukchi Sea by all vessels associated with exploration drilling may take well into the month of November due to ice, weather, and sea states.

Exploration Drilling

All drill sites at which exploration drilling would occur in 2015 will be at Shell's Burger Prospect as described in the Revised Chukchi Sea EP submitted to BOEM. Shell has identified a total of six Chukchi Sea lease blocks on the Burger Prospect. All six drill sites listed in Table 2-1 are located more than 64 mi (103 km) off the Chukchi Sea coast. During 2015, the *Discoverer* and *Polar Pioneer* will be used to conduct exploration drilling activities at up to four exploration drill sites. As with any Arctic exploration program, weather and ice conditions will dictate actual operations.

Activities associated with the Chukchi Sea exploration drilling program and analyzed herein include operation of the *Discoverer*, *Polar Pioneer*, and associated support vessels. The drilling units will remain at the location of the designated exploration drill sites except when mobilizing and demobilizing to and from the Chukchi Sea, transiting between drill sites, and temporarily moving off location if it is determined ice conditions require such a move to ensure the safety of personnel and/or the environment.

Table 2-1 Drill Site Locations and Water Depths

Drill Site	Approximate Distance from shore (statute miles)	Lease Block No.	Surface Location (NAD 83)		Water Depth
			Latitude (north)	Longitude (west)	Feet/Meters
Burger A[1]	75	6764	71° 18' 30.92"	163° 12' 43.17"	150/45.8
Burger F	76	6714	71° 20' 13.96"	163° 12' 21.75"	149/45.4
Burger J	69	6912	71° 10' 24.03"	163° 28' 18.52"	144/44.0
Burger R	75	6812	71° 16' 06.57"	163° 30' 39.44"	143/43.7
Burger S	78	6762	71° 19' 25.79"	163° 28' 40.84"	147/44.9
Burger V	65	6915	71° 10' 33.39"	163° 04' 21.23"	147/44.7

[1] Burger A drill site where a partial well was begun in 2012

3. SPECIES AND NUMBERS OF MARINE MAMMALS

Marine mammals that occur in the area of the planned exploration drilling activities belong to three taxonomic groups: odontocetes (toothed cetaceans, such as beluga whale and narwhal), mysticetes (baleen whales), and carnivora (pinnipeds and polar bears). Cetaceans and pinnipeds (except Pacific walrus) are the subject of this IHA application to the NMFS. The Pacific walrus and polar bear are managed by the U.S. Fish & Wildlife Service (USFWS) and are not discussed further in this application.

Marine mammal species under the jurisdiction of the NMFS that are known to or may occur in the area of the planned exploration drilling activities include nine cetacean species and four species of pinnipeds. Three of these species, the bowhead, humpback, and fin whales are listed as “endangered” under the Endangered Species Act (ESA). The bowhead whale is more common in the area than the other two species. The fin whale is unlikely to be encountered near the planned activities, but a few sightings in the Chukchi Sea have been reported in recent years (Reiser et al. 2009a; Hartin et al. 2013; Bisson et al. 2013; Clarke et al. 2013). Similarly, humpback whales are not known to regularly occur in the Chukchi Sea; however, several humpback sightings have been recorded during vessel-based and aerial surveys in the Chukchi Sea (Reiser et al. 2009a, Clarke et al. 2011; Bisson et al. 2013; Clarke et al. 2013). Two species of seal (ringed seal and bearded seal) were recently been listed as “threatened” species under the ESA (NMFS 2012a,b). On July 25, 2014 the U.S. District Court for the District of Alaska vacated the listing rule with respect to the Beringia bearded seal distinct population segment (DPS) and remanded the rule to the NMFS to correct the deficiencies identified in the opinion. The Beringia DPS is not considered a listed species (identified as “Candidate” in Table 4-1), but the listing is still in effect for the Okhotsk DPS (which is located in the Okhotsk Sea off the coast of Russia). Both species are common and abundant in the Chukchi Sea.

The North Pacific right whale and Steller sea lion, both listed as “endangered” under the ESA, are not found in the Alaska Chukchi Sea, but do occur in the Bering Sea, through which the vessels will pass in route to the drill sites. The North Pacific right whale and Steller sea lion are not expected to be in the vicinity of drilling activities, but may overlap in space and time with vessels transiting the Bering Sea in route to or from the Chukchi Sea. In NOAA’s 2013 Biological Opinion (BO) for oil and gas exploration activities in the Chukchi and Beaufort Seas (NOAA 2013c), the agency analyzed potential effects of an expanded project area that included portions of the Bering Sea where Steller sea lions and North Pacific right whales may be affected. In turn, the NMFS analyzed the effects of oil and gas exploration activities on those species. Although transiting vessels in the Bering Sea could encounter species, the North Pacific right whale and Steller sea lion are not found in the Chukchi Sea and incidental take is not being sought for these species in this application.

To avoid redundancy, we have included the required information about the species that are known to or may be present in the area where exploration activities will be taking place below in Section 4.

4. AFFECTED SPECIES STATUS AND DISTRIBUTION

Sections 3 and 4 are integrated here to minimize repetition.

The Marine mammal species under NMFS jurisdiction most likely to occur in the area of the planned exploration drilling activities in the Chukchi Sea include four cetacean species (beluga, bowhead and gray whales, and harbor porpoise) and three pinniped species (ringed, bearded, and spotted seals). Densities of marine mammals in these areas are likely to be higher if the ice edge occurs nearby. The marine mammal species that is likely to be encountered most widely throughout the exploration drilling activities is the ringed seal. Encounters with bowhead and gray whales are expected to be limited to particular seasons, as discussed below.

Table 4-1 The Habitat, Abundance, and Conservation Status of Marine Mammals Inhabiting the Area

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
Odontocetes Beluga whale (*Delphinapterus leucas*) (Eastern Chukchi Sea Stock)	Offshore, Coastal, Ice edges	3,710[4]	Not listed	NT	–
Beluga whale (Beaufort Sea Stock)	Offshore, Coastal, Ice edges	39,258[5]	Not listed	NT	–
Narwhal (*Monodon monoceros*)	Offshore, Ice edge	Rare[6]	Not listed	NT	–
Killer whale (*Orcinus orca*)	Widely distributed	2,084[7]	Not listed	DD	–
Harbor Porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters, shallow offshore waters	48,215[4] Common[8]	Not listed	LC	–
Mysticetes Bowhead whale (*Balaena mysticetus*)	Pack ice, coastal	19,534[9]	Endangered	LC	I
Gray whale (*Eschrichtius robustus*) (Eastern Pacific population)	Coastal, lagoons, shallow offshore waters	19,126[10]	Not listed	LC	I
Minke whale (*Balaenoptera acutorostrata*)	Shelf, coastal	810[11]	Not listed	LC	I
Fin whale (*Balaenoptera physalus*)	Slope, mostly pelagic	1,652[12]	Endangered	EN	I
Humpback whale (*Megaptera novaeangliae*)	Shelf, coastal	20,800[13]	Endangered	LC	I
Pinnipeds Bearded seal (*Erignathus barbatus*)	Pack ice, shallow offshore waters	155,000[14]	Candidate[19]	LC	–
Spotted seal (*Phoca largha*)	Pack ice, coastal haulouts, offshore	~141,479[15]	Arctic pop. segments not listed	DD	–
Ringed seal (*Pusa hispida*)	Landfast & pack ice, offshore	300,000[16]	Threatened	LC	–
Ribbon seal (*Histriophoca fasciata*)	Pack ice, offshore	90-100,000[17] 49,000[18]	Not Listed	DD	–

1 U.S. Endangered Species Act.
2 Red List of Threatened Species (IUCN 2013). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient
3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2013)
4 Allen and Angliss (2014)
5 Beaufort Sea populations (Allen and Angliss 2014)
6 Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2010); very few in Alaska (Allen and Angliss 2014)
7 Minimum estimate for Eastern Chukchi and Beaufort Sea (Allen and Angliss 2014)
8 Vessel-based observations from Industry activities in 2006–2010 (Hartin et al. 2013)
9 2011 B-C-B Bowhead population estimate with annual growth rate of 3.7% (Givens et al. 2013)
10 North Pacific gray whale population (Laake et al. 2009)
11 Allen and Angliss 2014 (from Moore et al. 2002)
12 Allen and Angliss 2014 (from Zerbini et al. 2006)
13 Allen and Angliss 2014, estimate for entire North Pacific population
14 Beringia Distinct Population Segment (Cameron et al. 2010)
15 Central and Eastern Bering Sea stock based on aerial surveys in 2007 (Allen and Angliss 2014)
16 Allen and Angliss 2014, based on recent provisional estimate by Boveng et al. 2008
17 Bering Sea, (Burns 1981a)
18 Eastern and Central Bering Sea (Allen and Angliss 2014)
19 On July 25, 2014 the U.S. 9th district court vacated the listing rule with respect to the Beringia bearded seal DPS and remanded the rule to NMFS to correct the deficiencies identified in the opinion. The Beringia DPS is not listed (identified as “Candidate”), but the listing is still in effect for the Okhotsk DPS (which is located in the Okhotsk Sea off the coast of Russia).

Five additional cetacean species; the narwhal, killer whale, minke whale, humpback whale, and fin whale could occur, but each of these species are uncommon or rare in the project area, and relatively few encounters with these species is expected during the exploration drilling program. Humpback and fin whales occur in very low numbers in the project area, but may be regular visitors (Allen and Angliss, 2014). The narwhal occurs in Canadian waters and occasionally in the Alaskan Beaufort Sea and the Chukchi Sea, but are considered extralimital in U.S. waters and not expected to be encountered.

Reliable population estimates for many species of marine mammals found in the activity area are not available. All of the marine mammal species found in the activity area belong to populations that exist in regions outside the Chukchi Sea at some point during their life histories. In many cases, population estimates exist for a species or stock, but are not specific to the activity area itself. The best available and relevant population information for each species found in the activity area is summarized in Table 4-1, including habitat, abundance estimate, and conservation status.

Odontocetes

(a) Beluga (Delphinapterus leucas)

The beluga whale is an Arctic and subarctic species that includes several populations in Alaska and northern European waters. It has a circumpolar distribution in the Northern Hemisphere and occurs between 50º and 80ºN latitude (Reeves et al. 2002). It is distributed in seasonally ice-covered seas and migrates to warmer coastal estuaries, bays, and rivers in summer for molting (Finley 1982).

Pod structure in beluga groups appears to be along matrilineal lines, with males forming separate aggregations. Small groups are often observed traveling or resting together. Belugas often migrate in groups of 100 to 600 animals (Braham and Krogman 1977). The relationships between whales within groups are not known, although hunters have reported that belugas form family groups with whales of different ages traveling together (Huntington 2000).

In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For Shell's planned activities, only the Beaufort Sea and eastern Chukchi Sea stocks may be encountered.

The most recent estimate of the eastern Chukchi Sea population is 3,710 animals (Allen and Angliss 2014). This estimate was based on surveys conducted in 1989–1991. Survey effort was concentrated on the 106 mi (171 km) long Kasegaluk Lagoon where belugas are found during the open-water season. The actual number of beluga whales recorded during the surveys was much lower. Correction factors to account for animals that were underwater and for the proportion of newborns and yearlings that were not observed due to their small size and dark coloration were used to calculate the estimate. The calculation was considered to be a minimum population estimate for the eastern Chukchi Sea stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable. It is assumed that beluga whales from the eastern Chukchi stock winter in the Bering Sea (Allen and Angliss 2014).

Although beluga whales are known to congregate in Kasegaluk Lagoon during summer, evidence from a small number of satellite-tagged animals suggests that some of these whales may subsequently range into the Arctic Ocean north of the Beaufort Sea. Suydam et al. (2005) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July 1998–2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79–80°N latitude. These and other whales moved to areas as far as 685 mi (1,102 km) offshore between Barrow and the Mackenzie River Delta spending time in water with 90 percent ice coverage.

No belugas were observed from vessels during the 2008 to 2012 Chukchi Sea Environmental Science Program (Aerts et al. 2013). However, beluga calls were identified from acoustic recordings at several acoustic stations in the Chukchi Sea; the majority of calls were detected from April to early June (Delarue et al. 2011). From 2006 through 2010 there were only 5 sightings of beluga whales in the Chukchi Sea from industry vessels conducting various seismic survey and support operations (Hartin et al. 2013). Neither visual observations nor acoustic detections of belugas occurred during Chukchi Acoustic, Oceanography, and Zooplankton (CHAOZ) studies in 2010 and 2011 which occurred during the months of August through September in both years (NOAA 2010, 2011).

During aerial surveys in nearshore areas (within approximately (~) 23 mi (~37 km) of the coast) in the Chukchi Sea in 2006-2010, peak beluga sighting rates were recorded in July. Lowest monthly sighting rates were recorded in September (Thomas and Koski 2013). When data from the three years were pooled, beluga whale sighting rates and number of individuals were highest in the band 16-19 mi (25-30 km) offshore. However the largest single groups were sighted at locations near shore in the band within 3 mi (5 km) of the shoreline. During offshore aerial surveys in summer and fall of 2008–2010 beluga whales were seen in every month except September (Clarke at al. 2011). Approximately 40 percent of sightings (73 percent of individuals) occurred in July and all sightings occurred within 150 km of shore. More belugas were observed during 2011 and 2012 surveys (Clarke et al. 2012, 2013), primarily from the observation of large groups near the coast south of Pt. Lay in June and July. The fewest number of belugas were observed in August and September of those years.

Beluga whales from the eastern Chukchi Sea stock are an important subsistence resource for residents of the village of Point Lay, adjacent to Kasegaluk Lagoon, and other villages in northwest Alaska. Each year, hunters from Point Lay drive belugas into the lagoon to a traditional hunting location. The belugas have been predictably sighted near the lagoon from late-June through mid- to late-July (Suydam et al. 2001b). In 2007, approximately 70 belugas were also harvested at Kivalina located southeast of Point Hope.

Belugas of the eastern Chukchi Sea population could occur in the vicinity of the planned drilling activities throughout the summer months. Based on the results of satellite telemetry data at least some of this stock may also pass the project area during fall migration; however, data from Thomas et al. (2009) suggests the highest concentration of belugas may be expected to occur much closer to shore than Shell’s planned exploration drilling activities.

The Beaufort Sea population was estimated to contain 39,258 individuals as of 1992 (Allen and Angliss 2014). This estimate was based on the application of a sightability correction factor of 2× to the 1992 uncorrected census of 19,629 individuals made by Harwood et al. (1996). This estimate was obtained from a partial survey of the known range of the Beaufort Sea population and may be an underestimate of the true population size. This population is not considered by NMFS to be a strategic stock and is believed to be stable or increasing (Allen and Angliss 2014).

Beluga whales of the Beaufort Sea stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate in offshore waters of western and northern Alaska (Allen and Angliss 2014). The majority of belugas in the Beaufort Sea stock migrate through the Chukchi Sea and into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late-March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995b). Fall migrant beluga whales from the Canadian Beaufort Sea transit the Alaskan Beaufort Sea in a more dispersed pattern, but often along the southern edge of the pack ice, to reach western Chukchi Sea waters primarily during September (Richard et al. 1998). During this time, pods can exceed 1,000 individuals (Citta and Lowry 2008). Beluga whales associated with the Beaufort Sea population would be most likely to occur near the planned exploration drilling activities during fall migration through the Chukchi Sea.

(b) Narwhal (Monodon Monoceros)

Narwhals have a discontinuous Arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002). A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, while much smaller numbers inhabit the Northeast Atlantic/East Greenland area. The International Union for the Conservation of Nature (IUCN)-World Conservation Union lists the species as “near threatened” (IUCN 2013). Aerial surveys over four hunting grounds off the coast of Greenland in 2006 yielded abundance estimates between 6,024 and 8,368 individuals in each area (Heide-Jørgensen et al. 2010). Innes et al. (2002) estimated a population size of 45,358 narwhals in the Canadian Arctic although little of the area was surveyed. More recent surveys of portions of Baffin Bay in the Canadian High Arctic resulted in a total population estimate of >60,000 individuals (Richard et al. 2010). The Alaskan Beaufort Sea is not defined as a portion of a narwhal population’s range and it is considered extralimital in this region (Allen and Angliss 2014). However, there are scattered records of narwhal in Alaskan waters. Thus, it is possible, but very unlikely, that individuals could be encountered in the area of the planned exploration drilling activities in the Chukchi Sea.

(c) Killer Whale (*Orcinus orca*)

Killer whales are cosmopolitan and globally fairly abundant. The killer whale is very common in temperate waters, but it also frequents the tropics and waters at high latitudes. Killer whales appear to prefer coastal areas, but are also found in deep water (Dahlheim and Heyning 1999). The greatest abundance is thought to be within 497 mi (800 km) of major continents (Mitchell 1975) and the highest densities occur in areas with abundant prey. Killer whales from either resident or transient stocks could occur in the Chukchi Sea during summer or fall, although transients would be more likely (Allen and Angliss 2014). Transient and resident ecotypes are believed to differ in several aspects of morphology, ecology, and behavior including dorsal fin shape, saddle patch shape, pod size, home range size, diet, travel routes, dive duration, and social integrity of pods (Allen and Angliss 2014).

Killer whales are known to inhabit almost all coastal waters of Alaska, extending from southeast Alaska through the Aleutian Islands to the Bering and Chukchi seas (Allen and Angliss 2014). Killer whales probably do not occur regularly in the Beaufort Sea, although sightings have been reported (Lowry et al. 1987, George and Suydam 1998). George et al. (1994) reported that they and local hunters see a few killer whales at Point Barrow each year. Killer whales are more common southwest of Barrow in the southern Chukchi Sea and the Bering Sea. Based on photographic techniques, ~100 animals have been identified in the Bering Sea (ADFG 1994).

The number of killer whales likely to occur in the Chukchi Sea during the planned activity is quite small. PSOs onboard industry vessels in the Chukchi Sea have recorded 1-2 killer whale sightings in most years since 2006 (Funk et al. 2010; Reiser et al. 2011; Hartin et al. 2013; Bisson et al. 2013). Observers on Chukchi Sea Environmental Studies Program (CSESP) vessels reported two sightings of killer whales in 2008 and three sightings of 41 individuals in 2012 (Aerts et al. 2013). No visual or acoustic detections were recorded during CHAOZ surveys in 2010–2011 (NOAA 2010, 2011). Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) aerial surveys in 2008–2011 did not detect any killer whales (Clarke et al. 2011, 2012); however, two sightings of 18 killer whales were recorded in 2012 (Clarke et al. 2013).

(d) Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise is a small odontocete that inhabits shallow, coastal waters—temperate, subarctic, and arctic in the Northern Hemisphere (Read 1999). Harbor porpoises occur mainly in shelf areas where they can dive to depths of at least 722 ft. (220 m) and stay submerged for more than 5 minutes (Harwood and Wilson 2001) feeding on small schooling fish (Read 1999). Harbor porpoises typically occur in small groups of only a few individuals and tend to avoid vessels (Richardson et al. 1995a).

The subspecies *Phocoena phocoena vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the southeastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of their regular range (Suydam and George 1992), though there are extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada and recent sightings in the Beaufort Sea in the vicinity of Prudhoe Bay during surveys in 2007 and 2008 (Lyons et al. 2009).

Although separate harbor porpoise stocks for Alaska have not been identified, Alaskan harbor porpoises have been divided into three groups for management purposes. These groups include animals from southeast Alaska, Gulf of Alaska, and Bering Sea populations. Harbor porpoises present in the Chukchi Sea belong to the Bering Sea group, which includes animals from Unimak Pass northward. Based on aerial surveys in 1999, the Bering Sea population was estimated at 48,215 animals; although this estimate is likely conservative as the surveyed area did not include known harbor porpoise range near the Pribilof Islands or waters north of Cape Newenhan ~55°N latitude (Allen and Angliss 2014). Suydam and George (1992) suggested that harbor porpoises occasionally occur in the Chukchi Sea and reported nine records of harbor porpoise in the Barrow area in 1985–1991.

More recent vessel-based surveys in the Chukchi Sea found that harbor porpoise were commonly encountered during summer and fall from 2006 to 2010 (Hartin et al. 2013). There were 14 sightings of harbor porpoises during 2008–2012 CSESP surveys and several sightings of harbor porpoises during CHAOZ surveys north of Point Hope (Aerts et al. 2013; NOAA 2010, 2011).

Mysticetes

(a) Bowhead Whale (Balaena mysticetus)

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunct circumpolar distribution (Reeves 1980). The bowhead is one of only three whale species that spend their entire lives in the Arctic. Bowhead whales are found in four areas: the western Arctic (Bering, Chukchi, and Beaufort seas) of northeastern Russia, Alaska and northwestern Canada; the Canadian High Arctic and West Greenland (Nunavut, Baffin Bay, Davis Strait, and Hudson Bay); the Okhotsk Sea (eastern Russia); and the Northeast Atlantic from Spitzbergen westward to eastern Greenland. The largest stock is the Western Arctic or Bering–Chukchi–Beaufort (BCB) stock. The BCB stock of bowheads includes whales that winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea, and Alaskan Beaufort Sea to the Canadian Beaufort Sea where they feed during the summer. These whales migrate west through the Alaskan Beaufort Sea in the fall as they return to wintering areas in the Bering Sea. Visual and satellite tracking data show that many bowhead whales continue migrating west past Barrow and through the northern Chukchi Sea to Russian waters before turning southeast toward the Bering Sea (Moore et al. 1995; Mate et al. 2000; Quakenbush et al. 2010). Some bowheads reach ~75ºN latitude during the westward fall migration (Quakenbush et al. 2010). Prior to 2012, the majority of satellite-tagged whales crossed the Chukchi Sea quickly; however tagged whales in 2012 remained in the central Chukchi Sea concurrently with drilling operations before entering the Bering Sea in December, possibly due to opportunistic feeding (Quakenbush et al. 2013). Bowhead whales were encountered in the Chukchi Sea in mid-November in 2012 during other industry activities (LGL et al. 2014).

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort seas is estimated to have been 10,400-23,000 whales. Commercial whaling activities in the late-1800s and early-1900s may have reduced this population to as few as 3,000 animals (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2 percent per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). A census in 2001 yielded an estimated annual population growth rate of 3.4 percent (95 percent confidence interval [CI], 1.7–5 percent) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004; revised to 10,545 by Zeh and Punt 2005). A photo identification population estimate from data collected in 2004 estimated the population (in 2004) to be 12,631 (Koski et al. 2010), which further supports the estimated 3.4 percent population growth rate. Most recently, Givens et al. (2013) estimated the population to be 16,892 individuals in 2011. Assuming a continuing annual population growth of 3.7 percent (Givens et al. 2013), the 2015 BCB bowhead population may number around 19,534 animals. The large increases in population estimates that occurred from the late 1970s to the early 1990s were partly a result of actual population growth, but were also partly attributable to improved census techniques (Zeh et al. 1993). Although apparently recovering well, the BCB bowhead population is currently listed as endangered under the ESA and is classified as a strategic stock by NMFS and depleted under the MMPA (Allen and Angliss 2014).

The BCB stock of bowhead whales winters in the central and western Bering Sea and many of these whales summer in the Canadian Beaufort Sea (Moore and Reeves 1993). Spring migration through the Chukchi Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984; Moore and Reeves 1993), well before the onset of the planned exploration drilling activities.

Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most may remain among the offshore pack ice of the Beaufort Sea until mid- summer. After feeding primarily in the Canadian Beaufort Sea and Amundsen Gulf, bowheads migrate westward from late August through mid- or late-October. Fall migration into Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004, 2009a; Greene et al. 2007). Satellite tracking of bowheads has also shown that some whales move to the Chukchi Sea prior to September (Quakenbush et al. 2010).

Bowheads commonly interrupt their migration to feed along the Alaskan Beaufort Sea coast (Ljungblad et al. 1986; Lowry 1993; Landino et al. 1994; Würsig et al. 2002; Lowry et al. 2004) and their stop-overs vary in duration from a few hours to a few weeks (Koski et al. 2002). The nearest of these known feeding areas to the proposed operations in the Chukchi Sea is just east of Pt. Barrow, which is approximately 250 km from the Burger prospect.

Westbound bowheads typically reach the Barrow area in mid-September, and remain there until late October (e.g., Brower 1996). However, over the years, local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack ice off Barrow during the summer. Bowhead whales that are thought to be part of the Western Arctic stock may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh et al. 2003). Thomas et al. (2009) also reported bowhead sightings in 2006 and 2007 during summer aerial surveys in the Chukchi Sea. All sightings were recorded in the northern portion of the study area, north of 70ºN latitude. Autumn bowhead whaling near Barrow normally begins in mid-September to early October. Whaling near Barrow can continue into October or early November, depending on the available quota and weather conditions.

Bowhead densities estimated from data collected on industry vessels in the Chukchi Sea were higher in fall than summer in 2006, 2008, and 2010 with very little industry activity having occurred in 2009 and 2011 (Hartin et al. 2013). In 2007, bowhead whales were observed by aerial surveys feeding in the Beaufort Sea into September, which may have delayed the bowhead whale migration into the Chukchi and resulted in a reduction of fall sightings in the Chukchi Sea (Christie et al. 2010) in that year. During CSESP surveys in 2008 and 2009, all bowhead sightings occurred in October (Brueggeman et al. 2009, 2010). During the 2010 surveys all but one sighting occurred in October (Aerts et al. 2011). These sightings coincided with increased bowhead whale call detections on acoustic recorders during October of 2009 and 2010. Increases in bowhead whale call detections moved from the northeast array near Barrow to the southwest array from late September to December 2009, consistent with the overall southwest fall migration of bowhead whales through the Chukchi Sea (Delarue et al. 2011). Aerial surveys of offshore portions of the Chukchi Sea from 2008–2012 have shown a relatively consistent pattern of few bowhead whales being present in June–August, and then increasing numbers in September and October (Clarke et al. 2011, 2012, 2013).

Most spring-migrating bowhead whales would likely pass through the Chukchi Sea prior to the start of the planned exploration drilling activities. However, a few whales that may remain in the Chukchi Sea during the summer could be encountered during the drilling activities or by transiting vessels. More encounters with bowhead whales would be likely to occur during the westward fall migration in late September through October. An ongoing GPS tagging study (Quakenbush et al. 2013) has provided information on fall bowhead movements across the Chukchi Sea. Most bowheads migrating in September and October appear to transit across the northern portion of the Chukchi Sea to the Chukotka coast before heading south toward the Bering Sea (Quakenbush et al. 2009). Some of these whales have traveled well north of the planned operations, but others have passed near to, or through, the proposed project area. In addition to other planned mitigation, Shell will operate in consultation with stakeholders to avoid disturbance to subsistence bowhead whaling activities in the Chukchi Sea, should such a subsistence bowhead hunt occur during the period of Shell's planned 2015exploration drilling activities. There have been no known conflicts between industry and bowhead subsistence users in the Alaskan Arctic since the adoption of conflict avoidance measures in 2006.

(b) Gray Whale (Eschrichtius robustus)

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic populations are believed to have become extinct by the early 1700s. There are two populations in the North Pacific. A relic population, which survives in the Western Pacific, summers near Sakhalin Island far from the area of the planned exploration drilling activities. The larger eastern Pacific or California gray whale population recovered dramatically from commercial whaling during its protection under the MMPA (and ESA until 1994) and numbered about 29,758 ±3,122 in 1997 (Rugh et al. 2005). However, abundance estimates since 1997 indicate a consistent decline followed by the population stabilizing or gradually recovering. Rugh et al. (2005) estimated the population to be 18,178 ±1,780 in winter 2001-2002 and Rugh et al. (2008) estimated the population in winter 2006-2007 to have been 20,110 ±1,766. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Eastern Pacific gray whales calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the calving season, most of these gray whales migrate about 5,000 mi (8,000 km), generally along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (Tomilin 1957, Rice and Wolman 1971, Nerini 1984, Moore et al. 2003, Bluhm et al. 2007). Most gray whales begin the southward migration in November with breeding and conception occurring in early December (Rice and Wolman 1971).

Most summering gray whales have historically congregated in the northern Bering Sea, particularly off St. Lawrence Island in the Chirikov Basin (Moore et al. 2000), and in the southern Chukchi Sea. More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin has decreased, likely as a result of the combined effects of changing currents resulting in altered secondary productivity dominated by lower-quality food. Coyle et al. (2007) noted that ampeliscid amphipod production in the Chirikov Basin had declined by 50 percent from the 1980s to 2002-2003 and that as little as 3-6 percent of the current gray whale population could consume 10-20 percent of the ampeliscid amphipod annual production. This data supports the hypotheses that changes in gray whale distribution may be caused by changes in food production and that gray whales may be approaching or have surpassed the carrying capacity of their summer feeding areas. Bluhm et al. (2007) noted high gray whale densities along ocean fronts and suggested that ocean fronts may play an important role in influencing prey densities in eastern North Pacific gray whale foraging areas. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea southwest of Barrow (Clarke et al. 1989).

Gray whales routinely feed in the Chukchi Sea during the summer. Moore et al. (2000) reported that during the summer, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal shoal habitat. In autumn, gray whales were clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters southwest of Point Barrow at Hanna Shoal and northwest of Point Hope. The distribution of gray whales was different during aerial surveys in the Chukchi Sea in 2006 than in and 2007–2008 and 2010 (Thomas and Koski 2013). In 2006, gray whales were most abundant along the coast south of Wainwright and offshore of Wainwright (Thomas and Koski 2013). In the following years, gray whales were most abundant in nearshore areas from Wainwright to Barrow (Thomas and Koski 2013). Gray whales occur regularly near Point Barrow, but historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow.

Vessel based surveys also indicate that gray whales occur more frequently in nearshore waters of the Chukchi Sea. Approximately 90 percent of gray whales seen during CSESP surveys in 2012 occurred in waters close to Wainwright, similar to results from surveys in previous years (Aerts et. al 2013). Gray whales were primarily seen nearshore (<50 km) between Pt. Franklin and Pt. Barrow in the Chukchi Sea, despite extensive aerial survey effort further offshore from 2008–2012 (Clarke et al. 2011, 2012, 2013). Scattered sightings of gray whales further offshore do occur, and gray whales have been more common out to 100 km offshore between Icy Cape and Pt. Franklin than along other portions of the coast; however, the use of Hannah Shoal by gray whales appears to have decreased substantially compared to the 1982–1991 survey period (Moore et al. 2000). Gray whales are seen more frequently during July and August, with decreasing numbers of sightings through the fall months (Clarke et al. 2011, 2012, 2013).

Although they are most common in portions of the Chukchi Sea close to shore, gray whales may also occur in offshore areas of the Chukchi Sea, particularly over offshore shoals. Gray whales are likely to be in the vicinity of the planned exploration drilling activities in the Chukchi Sea and are likely to be one of the most commonly encountered cetacean species.

(c) Minke Whale (Balaenoptera acutorostrata)

Minke whales have a cosmopolitan distribution at ice-free latitudes (Stewart and Leatherwood 1985), and also occur in some marginal ice areas. Allen and Angliss (2014) recognize two minke whale stocks in U.S. waters: (1) the Alaska stock, and (2) the California/Oregon/ Washington stock. There is no abundance estimate for the Alaska stock. Provisional estimates of minke whale abundance based on surveys in 1999 and 2000 are 810 and 1003 whales in the central-eastern and south-eastern Bering Sea, respectively. These estimates have not been corrected for animals that may have been submerged or otherwise missed during the surveys, and only a portion of the range of the Alaskan stock was surveyed. Minke whales range into the Chukchi Sea, but the level of minke whale use of the Chukchi Sea is unknown.

Minke whales have been observed from vessels during previous industry activities in the Chukchi Sea (Hartin et al. 2013; Bisson et al. 2013; Reider et al. 2013) and during aerial surveys conducted by the National Marine Mammal Laboratory (NMML) in 2011 and 2012 (Clarke et al. 2012, 2013). Reider et al. (2013) reported 13 minke whale sightings in the Chukchi Sea in 2013 during Shell’s marine survey program. All but one sighting, however, were observed in nearshore areas despite only minimal monitoring effort in nearshore areas compared to more offshore locations near the Burger prospect (Reider et al. 2013). Minke whales have been observed 10 times during CSESP vessel surveys from 2008 to 2012 (Aerts et al. 2013). Minke whales could be encountered in relatively low numbers during the planned activities in the Chukchi Sea.

(d) Fin Whale (Balaenoptera physalus)

Fin whales are widely distributed in all the world's oceans (Gambell 1985), but typically occur in temperate and polar regions. Fin whales feed in northern latitudes during the summer where their prey includes plankton, as well as shoaling pelagic fish, such as capelin *Mallotus villosus* (Jonsgård 1966a,b). The North Pacific population’s summering grounds span from the Chukchi Sea to California (Gambell 1985). Reliable population estimates for the entire North Pacific region are not available (Allen and Angliss 2014). Provisional estimates of fin whale abundance in the central-eastern and southeastern

Bering Sea are 3,368 and 683, respectively. Combined with an estimate from the Aleutian Islands, the population west of the Kenai Peninsula may be ~5,700 (Allen and Angliss 2014). No estimates for fin whale abundance during the summer in the Chukchi Sea are available. Fin whale is listed as "endangered" under the ESA and by the IUCN (2013), and in the North Pacific is classified as a strategic stock by NMFS.

Reiser et al. (2009a) reported a fin whale sighting during vessel-based surveys in the Chukchi Sea in 2006. Three fin whale sightings were made in 2008 from industry vessels and NMML survey aircraft also recorded a sighting in the northern Chukchi Sea off of Ledyard Bay in that year (Hartin et al. 2013; Clarke et al. 2011). Observers on CSESP vessel-based surveys recorded one fin whale sighting of three individuals in 2009 and six sightings of 11 individuals in 2012 (Aerts et al. 2013). In 2012, Aerial Surveys from the Arctic Marine Mammals Project (ASAMM) reported three fin whale sightings, all of which were south of Pt. Hope (Clarke et al. 2013), while one sighting was reported from an industry vessel (Bisson et al. 2013). Fin whale calls have been identified on acoustic recordings in the Chukchi Sea by multiple researchers in multiple years (NOAA 2011; Delarue et al. 2012).

(e) Humpback Whale (Megaptera novaeangliae)

Humpback whales are distributed in major oceans worldwide (Allen and Angliss 2014). In general, humpback whales spend the winter in tropical and sub-tropical waters where breeding and calving occur, and migrate to higher latitudes for feeding during the summer.

Humpback whales were hunted extensively during the 20th century and worldwide populations may have been reduced to ~10 percent of their original numbers. The International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean in 1965 and humpbacks were listed as "endangered" under the ESA and depleted under the MMPA in 1973. Most humpback whale populations appear to be recovering well.

Humpbacks feed on euphausiids, copepods, and small schooling fish, notably herring, capelin, and sandlance (Reeves et al. 2002). As with other baleen whales, the food is trapped or filtered when large amounts of water are taken into the mouth and forced out through the baleen plates. Individual humpback whales can often be identified by distinctive patterns on the tail flukes. They are frequently observed breaching or engaged in other surface activities.

Allen and Angliss (2014) reported that at least three humpback whale populations have been identified in the North Pacific. Two of these stocks may be relevant to the planned drilling activities in the Chukchi Sea. The Central North Pacific stock winters in waters near Hawaii and migrates to British Columbia, Southeast Alaska, and Prince William Sound to Unimak Pass to feed during the summer. The Western North Pacific stock winters off the coast of Japan and probably migrates to the Bering Sea to feed during the summer. There may be some overlap between the Central and Western North Pacific stocks.

Humpback whale sightings in the Bering Sea have been recorded southwest of St. Lawrence Island, the southeastern Bering Sea, and north of the central Aleutian Islands (Moore et al. 2002, Allen and Angliss 2014). Recently there have been sightings of humpback whales in the northeastern Chukchi Sea and a single sighting in the Beaufort Sea (Hashagen et al. 2009). Hartin et al. (2013) reported four humpback whales during vessel-based surveys in the Chukchi Sea in 2007, two in 2008, and one in 2010. Five humpback sightings (11 individuals) occurred during CSESP vessel-based surveys in 2009 and 2010 (Aerts et al. 2012), and a single humpback was observed several kilometers west of Barrow during the 2012 CSESP vessel-based survey (Aerts et al. 2013). The ASAMM reported four humpback whale sightings near the coast between Icy Cape and Pt. Barrow in July and August of 2012, as well as 24 individual humpback whales on 11 September south and east of Pt. Hope (Clarke et al. 2013). Prior to 2012 only a single humpback had been sighted during the ASAMM (Clarke et al. 2011). Small numbers of humpback whales could occur within or near the exploration drilling activities in the Chukchi Sea.

Pinnipeds

(a) Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981b). In Alaskan waters, bearded seals occur over the continental shelves of the Bering, Chukchi, and Beaufort seas (Burns 1981b). No reliable estimate of bearded seal abundance is available for the Chukchi Sea (Allen and Angliss 2014). However, the Alaska stock of bearded seals is estimated to be about 155,000 (Beringia DPS, Cameron et al. 2010) and was listed as threatened under the ESA (NMFS 2012a). On July 25, 2014 the U.S. District Court for the District of Alaska vacated the listing rule with respect to the Beringia bearded seal DPS and remanded the rule to NMFS to correct the deficiencies identified in the opinion. The Beringia DPS is not listed, but the listing is still in effect for the Okhotsk DPS (which is located in the Okhotsk Sea off the coast of Russia).

Bearded seals are primarily benthic feeders, preferring a variety of infaunal and epifaunal invertebrates as well as occasional demersal fishes (Bluhm and Gradinger 2008). They apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas where water depth is considerably greater than 656 ft. (200 m) (Cameron et al. 2009). During the summer period, bearded seals occur mainly in relatively shallow areas because they are predominantly benthic feeders (Burns 1981b).

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter, most bearded seals in Alaskan waters are found in the Bering Sea. In the Chukchi and Beaufort seas, favorable conditions are more limited, and consequently, bearded seals are less abundant there during winter; although they have occasionally been reported to maintain breathing holes in sea ice and broken areas within the pack ice, particularly if the water depth is <200 m [<656 ft.] (e.g., Harwood et al. 2005). From mid-April to June as the ice recedes, some of the bearded seals that overwintered in the Bering Sea migrate northward through the Bering Strait. During the summer they are found near the widely fragmented margin of sea ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea.

Bengtson et al. (2005) reported bearded seal densities in the Chukchi Sea ranging from 0.18 to 0.36 seals/square mile (mi^2) (0.07 to 0.14 seals/square kilometers [km^2]) in 1999 and 2000, respectively. No population estimates could be calculated since these densities were not adjusted for haulout behavior. Bearded seals are common in offshore pack ice, but there have been high bearded seal numbers observed near the shore south of the project area near Kivalina. Hartin et al. (2013) reported bearded seal densities ranging from 0.03 to 0.23 seals/mi^2 (0.01 to 0.09 seals/km^2) in the summer and fall, respectively, during vessel-based surveys in the Chukchi Sea. These densities were lower than those reported by Bengtson et al. (2005) but are not directly comparable since the latter densities were based on aerial surveys of seals on sea ice in late May and early June. Vessel-based surveys conducted annually from 2008–2011 as a part of the CSESP reported between 9 and 45 bearded seals on the Burger prospect annually. Density estimates from these sightings ranged from 0.014 to 0.035 seals/km^2 (0.036 to 0.091 seals/mi^2; Aerts et al. 2012).

Bearded seals are likely to be encountered during exploration drilling activities, and greater numbers of bearded seals are likely to be encountered if the ice edge occurs nearby.

(b) Spotted Seal (*Phoca largha*)

Spotted seals (also known as largha seals) occur in the Beaufort, Chukchi, Bering, and Okhotsk seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). They migrate south from the Chukchi Sea and through the Bering Sea in October (Lowry et al. 1998). Spotted seals overwinter in the Bering Sea and inhabit the southern margin of the ice during spring (Shaughnessy and Fay 1977).

An early estimate of the size of the world population of spotted seals was 370,000–420,000, and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000–250,000 animals (Bigg 1981). During the summer, spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. The total number of spotted seals in Alaskan waters is not known (Allen and Angliss 2014), but based on aerial surveys conducted in 2007, Allen and Angliss (2014) estimate the Alaskan population at 141,479 animals. The Alaska stock of spotted seals is not classified as endangered, threatened, or as a strategic stock by NMFS (Allen and Angliss 2014); although the southern distinct population segment of spotted seals was recently listed as a threatened species, it occurs entirely outside of U.S. waters.

During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Sub-adults may be seen in larger groups of up to 200 animals. During the summer, spotted seals are found primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. Spotted seals are commonly seen in bays, lagoons and estuaries, but also range offshore as far north as 69–72ºN latitude. In summer, they are rarely seen on the pack ice, except when the ice is very near shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998).

In the Chukchi Sea, Kasegaluk Lagoon and Icy Cape are important areas for spotted seals. Spotted seals haul out in this region from mid-July until freeze-up in late October or November. Lowry et al. (1998) reported a maximum count of about 2,200 spotted seals in the lagoon during aerial surveys. No spotted seals were recorded along the shore south of Pt. Lay. Based on satellite tracking data, Frost et al. (1993) reported that spotted seals tagged at Kasegaluk Lagoon spent 94 percent of the time at sea. Extrapolating the count of hauled-out seals to account for seals at sea would suggest a Chukchi Sea population of about 36,000 animals.

CSESP vessel-based surveys from 2008–2012 recorded 217 spotted seals as well as 756 seals that could not be identified as either ringed or spotted seals (Aerts et al. 2013). Observers aboard industry vessels operating in the Chukchi Sea from 2008 to 2010 reported 288 sightings of 355 individual spotted seals (Hartin et al. 2013). Some of the 2035 unidentified seals recorded during those years were likely spotted seals as well. Spotted seals are expected to occur near the planned exploration drilling activities in the Chukchi Sea, but they will likely be fewer in number than ringed seals.

(c) Ringed Seal (*Phoca hispida*)

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (King 1983). They are closely associated with ice and, in the summer, they often occur along the receding ice edges or farther north in the pack ice. In the North Pacific, they occur in the southern Bering Sea and range south to the seas of Okhotsk and Japan. They are found throughout the Beaufort, Chukchi, and Bering seas (Allen and Angliss 2014). The Alaska stock, part of the Arctic subspecies of ringed seal, has been listed as threatened under the ESA (NMFS 2012b).

Ringed seals are year-round residents in the Chukchi and Beaufort seas and the ringed seal is the most frequently encountered seal species in the area. During winter, ringed seals occupy landfast ice and offshore pack ice of the Bering, Chukchi and Beaufort seas. In winter and spring, the highest densities of ringed seals are found on stable shorefast ice. However, in some areas where there is limited fast ice but wide expanses of pack ice, including the Beaufort Sea, Chukchi Sea and Baffin Bay, total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970, Stirling et al. 1982, Finley et al. 1983). Adult ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975) while some sub-adult ringed seals appear to winter near the pack-ice edge in the Bering Sea (Crawford et al. 2012). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5–8 weeks, and mate in late April and May (Smith 1973, Hammill et al. 1991, Lydersen and Hammill 1993).

No estimate for the size of the Alaska ringed seal stock is currently available (Allen and Angliss 2014). Past ringed seal population estimates in the Bering, Chukchi, and Beaufort area ranged from 1–1.5 million (Frost 1985) to 3.3–3.6 million (Frost et al. 1988). During aerial surveys in 1999, Bengtson et al. (2005) reported ringed seal densities offshore from Shishmaref to Barrow ranging from 1.0 to 9.6 seals/mi^2 (0.4 to 3.7 seals/km^2) and estimated the total Chukchi Sea population at 245,048 animals in 1999. Densities were higher in nearshore than offshore locations. During vessel-based observations from industry activities in the Chukchi Sea, Hartin et al. (2013) reported seal densities (assumed to be primarily ringed seals) from 0.125 to 2.1 seals/mi^2 (0.048 to 0.807 seals/km^2). CSESP vessel-based surveys from 2008–2012 recorded 311 ringed seals and 756 seals classified as either ringed or spotted (Aerts et al. 2013). Estimated densities from CSESP vessel-bases surveys from 2008–2012 for the combined ringed/spotted seal category ranged from 0.01 seals/mi^2 (0.004 seals/km^2) in July/August of 2009 to 0.3 seals/mi^2 (0.1 seals/km^2) in July/August of 2008 (Aerts et al. 2013). Ringed seal will likely be the most abundant marine mammal species encountered in the Chukchi Sea during exploration drilling operations.

(d) Ribbon Seal (*Histriophoca fasciata*)

Ribbon seals are found along the pack-ice margin in the southern Bering Sea during late winter and early spring and they move north as the pack ice recedes during late spring to early summer (Burns 1970, Burns et al. 1981a). Little is known about their summer and fall distribution, but Kelly (1988) suggested that they move into the southern Chukchi Sea, based on a review of sightings during the summer. However, ribbon seals appeared to be relatively rare in the northern Chukchi Sea. During recent vessel-based surveys from 2006 to 2012 there were only nine ribbon seal sightings among the total of 3,443 seal sightings identified to species (LGL et al. 2014). CSESP vessel-based observers recorded six animals in 2008, none in 2009 and 2010, two in 2011, and none in 2012 (Aerts et al. 2013). Ribbon seals are expected to be rare in the planned project area in the Chukchi Sea.

5. TYPE OF INCIDENTAL TAKING AUTHORIZATION REQUESTED

Shell requests an IHA pursuant to Section 101(a)(5)(D) of the MMPA for incidental take by harassment of small numbers of whales and seals during its planned explorations drilling activities in the Chukchi Sea during exploration drilling activities.

The activities outlined in sections 1 and 2 have the potential to take marine mammals by “Level B” harassment as a result of sound energy introduced to the marine environment. Sounds that may “harass” marine mammals will include continuous sounds generated by drilling and related support activities, and pulsed sounds generated by the airguns used during ZVSP surveys. The effects will depend on the species of whale or seal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level (RL) of the sound. Disturbance reactions are likely to vary among some of the marine mammals in the general vicinity of the sound source. No “take” by serious injury is reasonably expected, given the nature of the specified activities and the mitigation measures that are planned. No lethal takes are expected (NMFS 2012c).

6. TAKE ESTIMATES FOR MARINE MAMMALS

Shell seeks authorization for potential "taking" of small numbers of marine mammals under the jurisdiction of NMFS, in the planned area of exploration drilling in the Chukchi Sea, for underwater sound from exploration drilling, MLC construction, anchor handling while mooring a drilling unit at a drill site, vessels on DP when tending to a drilling unit at a drill site, ice management, and ZVSP surveys. Species most likely to be encountered include bowhead and gray whales, beluga, harbor porpoise, and ringed, spotted, and bearded seals. Exposure estimates and requests for takes of ribbon seal, fin whale, humpback whale, killer whale, minke whale, and narwhal, but are minimal because sightings of these species in the Chukchi Sea are uncommon. It is reasonable to assume all representative sex and age classes of each marine mammal species could be present and "taken" during Shell's exploration drilling activities in 2015.

The only anticipated impacts to marine mammals are associated with exposure to underwater sound propagation from exploration drilling and ZVSP activities, potential icebreaking activities, and associated support vessels. Impacts would consist of temporary displacement of marine mammals from within ensonified zones produced by such sound sources and potential reductions in calling behavior (e.g., bowhead whale). Shell's planned exploration drilling activities in the Chukchi Sea are not expected to "take" more than small numbers of marine mammals, or have more than a negligible effect on their populations. Discussions of estimated "takes by harassment" are presented below.

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes. However, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures. In the sections below, we describe methods to estimate "take by harassment" and present estimates of the numbers of marine mammals that might be affected during the planned exploration drilling activities in the Chukchi Sea. The estimates are based on data obtained during marine mammal surveys in and near the planned exploration drilling sites and on estimates of the sizes of the areas where effects could potentially occur. Adjustments to reported population or density estimates were made to account for seasonal distributions and population increases or declines insofar as possible.

The main sources of distributional and numerical data used in deriving the estimates are described below. There is some uncertainty about the representativeness of those data and the assumptions used below to estimate the potential "take by harassment". However, the approach used here is the best available at this time.

Basis for Estimating "Take by Harassment"

"Take by Harassment" is calculated in this section by multiplying the expected densities of marine mammals that may occur near the exploration drilling activities by the area of water likely to be ensonified to continuous sounds ≥120 dB referenced 1 micropascal (dB re 1 μPa) rms from drilling-related activities or to pulsed sounds ≥160 dB re 1 μPa rms created by seismic airguns during ZVSP surveys.

Marine mammal occurrence near the activities is likely to vary by season and habitat, largely related to the presence or absence of sea ice and the migration timing and location for several species. This section provides descriptions of the estimated densities of marine mammals and areas of water exposed to the indicated sound levels over the course of the planned operations. There is no evidence that avoidance at received sound levels of ≥120 dB re 1 μPa rms or ≥160 dB re 1 μPa rms would have significant biological effects on individual animals or that the subtle changes in behavior or movements would "rise to the level of taking" according to guidance by the NMFS (2001). These behaviors have also been recognized by NMFS and incorporated into previous authorizations. For example, NMFS stated in the Notice of Issuance for Shell's 2012 drilling IHA in the Beaufort Sea (77 Fed. Reg. 27284, 27288 (May 9, 2012)), *"Bowheads may engage in avoidance behavior preventing their exposure to these levels of sound, and, even if exposed, may not exhibit a behavioral reaction."*

Also, NMFS states in the same notice,

"Although it is possible that marine mammals could react to any sound levels detectable above the ambient noise level within the animals' respective frequency response range, this does not mean that such a reaction would be considered a take. According to experts on marine mammal behavior, whether a particular stressor could potentially disrupt the migration, breathing, nursing, breeding, feeding, or sheltering, etc., of a marine mammal, i.e., whether it would result in a take, is complex and context specific, and it depends on several variables in addition to the received level of the sound by the animals." 77 Fed. Reg. at 27290.

Any changes in behavior caused by sounds at or near the specified received levels would likely fall within the normal variation in such activities that would occur in the absence of drilling activities. Nevertheless, Shell is conservatively assuming that all animals within the ensonified zones at or above Level B thresholds would be "taken" by harassment.

Marine Mammal Density Estimates

Marine mammal density estimates in the Chukchi Sea have been derived for two time periods, the summer period covering July and August, and the fall period including September and October. Animal densities encountered in the Chukchi Sea during both of these time periods will further depend on the habitat zone within which the activities are occurring: open water or ice margin. More ice is likely to be present in the area of activities during the July–August period, so summer ice-margin densities have been applied to 50 percent of the area that may be ensonified from drilling and ZVSP activities in those months. Open water densities in the summer were applied to the remaining 50 percent of the area. Less ice is likely to be present during the September–October period, so fall ice-margin densities have been applied to only 20 percent of the area that may be ensonified from drilling and ZVSP activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since ice management activities would only occur within ice-margin habitat, the entire area potentially ensonified by ice management activities has been multiplied by the ice-margin densities in both seasons.

As noted above, there is some uncertainty about the representativeness of the data and assumptions used in the calculations. To provide some allowance for the uncertainties, "maximum estimates" as well as "average estimates" of the numbers of marine mammals potentially affected have been derived. For a few marine mammal species, several density estimates were available. In those cases, the mean and maximum estimates were determined from the reported densities or survey data. In other cases only one or no applicable estimate was available, so correction factors were used to arrive at "average" and "maximum" estimates. These are described in detail in the following sections.

Detectability bias, quantified in part by $f(0)$, is associated with diminishing sightability with increasing lateral distance from the survey trackline. Availability bias, $g(0)$, refers to the fact that there is <100 percent probability of sighting an animal that is present along the survey trackline. Some sources below included these correction factors in the reported densities (e.g. ringed seals in Bengtson et al. 2005) and the best available correction factors were applied to reported results when they had not already been included (e.g. Moore et al. 2000).

<u>Cetaceans</u>

Nine species of cetaceans are known to occur in the activity area. Only four of these; bowhead and gray whales, beluga, and harbor porpoise are expected to be encountered in offshore areas during the planned exploration drilling activities. Three of the nine species; bowhead, fin, and humpback whales are listed as "endangered" under the ESA.

(a) Beluga Whales

Summer densities of beluga whales in offshore waters are expected to be low, with somewhat higher densities in ice-margin and nearshore areas. Past aerial surveys have recorded few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000). More recent aerial surveys of the Chukchi Sea from 2008-2012 flown by the NMML as part of the COMIDA project, now part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, reported 10 beluga sightings (22 individuals) in offshore waters during 22,154 km of on-transect effort. Larger groups of beluga whales were recorded in nearshore areas, especially in June and July during the spring migration (Clarke and Ferguson *in prep*; Clarke et al. 2012, 2013). Additionally, only one beluga sighting was recorded during >80,000 km of visual effort during good visibility conditions from industry vessels operating in the Chukchi Sea in September-October of 2006-2010 (Hartin et al. 2013). If belugas are present during the summer, they are more likely to occur in or near the ice edge or close to shore during their northward migration. Effort and sightings reported by Clarke and Ferguson (*in prep.*) and Clarke et al. (2012, 2013) were used to calculate the average open-water density estimate. The mean group size of the sightings was 2.2. A *f(0)* value of 2.841 and *g(0)* value of 0.58 from Harwood et al. (1996) were also used in the density calculation resulting in an average open-water density of 0.0024 belugas/km^2 (Table 6-1). The highest density from the reported survey periods (0.0049 belugas/km^2, in 2012) has been used as the maximum density that may occur in open-water habitat (Table 6-1). Specific data on the relative abundance of beluga in open-water versus ice-margin habitat during the summer in the Chukchi Sea is not available. However, belugas are commonly associated with ice, so an inflation factor of four was used to estimate the ice-margin densities from the open-water densities. Very low densities observed from vessels operating in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2010 (0.0-0.0003/mi^2, 0.0-0.0001/km$^{2)}$; (Hartin et al. 2013), also suggest the number of beluga whales likely to be present near the planned activities will not be large.

In the fall, beluga whale densities offshore in the Chukchi Sea are expected to be somewhat higher than in the summer because individuals of the eastern Chukchi Sea stock and the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Allen and Angliss 2014). Densities derived from survey results in the northern Chukchi Sea in Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) were used as the average density for open-water season estimates (Table 6-2). Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) reported 17 beluga sightings (28 individuals) during 22,255 km of on-transect effort in water depths 36–50 m during the months of July through September. The mean group size of those three sightings was 1.6. A *f(0)* value of 2.841 and a *g(0)* value of 0.58 from Harwood et al. (1996) were used to calculate the average open-water density of 0.0031 belugas/km^2 (Table 6-2). The highest density from the reported periods (0.0053 belugas/km^2, in 2012) was again used as the maximum density that may occur in open-water habitat. Moore et al. (2000) reported lower than expected beluga sighting rates in open-water during fall surveys in the Beaufort and Chukchi seas, so an inflation value of four was used to estimate the ice-margin densities from the open-water densities. Based on the few beluga sightings from vessels operating in the Chukchi Sea during non-seismic periods and locations in September-November of 2006-2010 (Hartin et al. 2013), the relatively low densities shown in Table 6-2 are consistent with what is likely to be observed form vessels during the planned exploration drilling activities.

(b) Bowhead Whales

By July, most bowhead whales are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea. No bowheads were reported during 10,686 km of on-transect effort in the Chukchi Sea by Moore et al. (2000). Bowhead whales were also rarely sighted in July-August of 2006-2010 during aerial surveys of the Chukchi Sea coast (Thomas and Koski 2013). This is consistent with movements of tagged whales (ADFG 2010), all of which moved through the Chukchi Sea by early May 2009, and tended to travel relatively close to shore, especially in the northern Chukchi

Sea. The estimate of the July-August open-water bowhead whale density in the Chukchi Sea was calculated from the three bowhead sightings (3 individuals) and 22,154 km of survey effort in waters 36-50 m deep in the Chukchi Sea during July-August reported in Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013). The mean group size from those sightings was 1. The group size value, along with a *f(0)* value of 2 and a *g(0)* value of 0.07, both from Thomas et al. (2002) were used to estimate a summer density of 0.0019 bowheads/km^2 (Table 6-1). The two sightings recorded during 4,209 km of survey effort in 2011 (Clarke et al. 2012) produced the highest annual bowhead density during July-August (0.0068 bowheads/km^2) which was used as the maximum open-water density (Table 6-1). Bowheads are not expected to be encountered in higher densities near ice in the summer (Moore et al. 2000), so the same density estimates have been used for open-water and ice-margin habitats. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2010 (Hartin et al. 2013) ranged from 0.0002-0.0008/km^2 with a maximum 95 percent CI of 0.0085/km^2. This suggests the densities used in the calculations and shown in Table 6-1 are similar to what are likely to be observed from vessels near the area of planned exploration drilling activities.

During the fall, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf migrate west and south to their wintering grounds in the Bering Sea making it more likely those bowheads will be encountered in the Chukchi Sea at this time of year. Moore et al. (2000) reported 34 bowhead sightings during 44,354 km of on-transect survey effort in the Chukchi Sea during September-October. Thomas and Koski (2013) also reported increased sightings on coastal surveys of the Chukchi Sea during October and November of 2006-2010. GPS tagging of bowheads appear to show that migration routes through the Chukchi Sea are more variable than through the Beaufort Sea (Quakenbush et al. 2010). Some of the routes taken by bowheads remain well north of the planned drilling activities while others have passed near to or through the area. Kernel densities estimated from GPS locations of whales suggest that bowheads do not spend much time (e.g. feeding or resting) in the north-central Chukchi Sea near the area of planned activities (Quakenbush et al. 2010). However, tagged whales did spend a considerable amount of time in the north-central Chukchi Sea in 2012, despite ongoing industrial activities in the region (ADFG 2012). Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) reported 72 sightings (86 individuals) during 22,255 km of on-transect aerial survey effort in waters 36-50 m deep in 2008-2012, the majority of which (53 sightings) were recorded in 2012. The mean group size of the 72 sightings was 1.2. The same *f(0)* and *g(0)* values that were used for the summer estimates above were used for the fall estimates resulting in an average September–October estimate of 0.0552 bowheads/km^2 (Table 6-2). The highest density form the survey periods (0.1320 bowheads/km^2; in 2012) was used as the maximum open-water density during the fall period. Moore et al. (2000) found that bowheads were detected more often than expected in association with ice in the Chukchi Sea in September-October, so the ice-margin densities that are used are twice the open-water densities. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in September-November of 2006-2010 (Hartin et al. 2013) ranged from 0.0003 to 0.0052/km^2 with a maximum 95 percent CI of 0.051/km^2. This suggests the densities used in the calculations and shown in Table 6-2 are somewhat higher than are likely to be observed from vessels near the area of planned exploration drilling activities.

Table 6-1 Expected Densities of Whales and Seals in Areas of the Chukchi Sea, Alaska for the Planned Summer (July–August) Period

	Open Water		Ice Margin	
Species	**Average Density (# / km²)**	**Maximum Density (# / km²)**	**Average Density (# / km²)**	**Maximum Density (# / km²)**
Odontocetes				
Monodontidae				
Beluga	0.0024	0.0049	0.0096	0.0196
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0022	0.0029	0.0022	0.0029
Mysticetes				
Bowhead whale	0.0019	0.0068	0.0019	0.0068
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0253	0.0268	0.0253	0.0268
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0003	0.0006	0.0003	0.0006
Pinnipeds				
Bearded seal[1]	0.0107	0.0203	0.0142	0.0270
Ribbon seal	0.0007	0.0028	0.0007	0.0028
Ringed seal	0.3668	0.6075	0.4891	0.8100
Spotted seal	0.0073	0.0122	0.0098	0.0162

[1]On July 25, 2014 the U.S. District Court for the District of Alaska vacated the listing rule with respect to the Beringia bearded seal DPS and remanded the rule to NMFS to correct the deficiencies identified in the opinion. The Beringia DPS is not listed, but the listing is still in effect for the Okhotsk DPS (which is located in the Okhotsk Sea off the coast of Russia)

*Species listed under the US ESA as Endangered or Threatened are in italics

(c) Gray Whales

Gray whale densities are expected to be much higher in the summer months than during the fall. Moore et al. (2000) found the distribution of gray whales in the planned operational area was scattered and limited to nearshore areas where most whales were observed in water less than 35 m deep. Thomas and Koski (2013) also reported substantial declines in the sighting rates of gray whales in the fall. The average open-water summer density (Table 6-1) was calculated from 2008–2012 aerial survey effort and sightings in Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) for water depths 36-50 m including 98 sightings (137 individuals) during 22,154 km of on-transect effort. The average group size of those sightings was 1.4. Correction factors $f(0)$ = 2.49 (Forney and Barlow 1998) and $g(0)$ = 0.30 (Forney and Barlow 1998, Mallonee 1991) were used to calculate and average open-water density of 0.0253 gray whales/km^2 (Table 6-1). The highest density from the survey periods reported in Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) was 0.0268 gray whales/km^2 in 2012 and this was used as the maximum open-water density. Gray whales are not commonly associated with sea ice, but may be present near it, so the same densities were used for ice-margin habitat as were derived for open-water habitat during both seasons. Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in July-August of 2006-2010 (Hartin et al. 2013) ranged from 0.0008/km^2 to 0.0085/km^2 with a maximum 95 percent CI of 0.0353 km^2.

In the fall, gray whales may be dispersed more widely through the northern Chukchi Sea (Moore et al. 2000), but overall densities are likely to be decreasing as the whales begin migrating south. A density calculated from effort and sightings (46 sightings [64 individuals] during 22,255 km of on-transect effort) in water 36-50 m deep during September–October reported by Clarke and Ferguson (*in prep*) and Clarke et al. (2012, 2013) was used as the average estimate for the Chukchi Sea during the fall period (0.0118 gray whales/km^2; Table 6-2). The corresponding group size value of 1.39, along with the same $f(0)$ and $g(0)$ values described above were used in the calculation. The maximum density from the survey periods (0.0248 gray whales/km^2) was reported in 2011 (Clarke et al. 2012) and used as the maximum fall open-water density (Table 6-2). Densities from vessel based surveys in the Chukchi Sea during non-seismic periods and locations in September-November of 2006-2010 (Hartin et al. 2013) ranged from 0.0/km^2 to 0.0044/km^2 with a maximum 95 percent CI of 0.0335 km^2.

(d) Harbor Porpoises

Harbor Porpoise densities were estimated from industry data collected during 2006-2010 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006–2010; however, recorded sightings throughout the Chukchi Sea during the summer and early fall months. Density estimates from 2006-2010 observations during non-seismic periods and locations in July-August ranged from 0.0013/km^2 to 0.0029/km^2 with a maximum 95 percent CI of 0.0137/km^2 (Hartin et al. 2013). The average density from the summer season of those three years (0.0022/km^2) was used as the average open-water density estimate while the high value (0.0029/km^2) was used as the maximum estimate (Table 6-1). Harbor porpoise are not expected to be present in higher numbers near ice, so the open-water densities were used for ice-margin habitat in both seasons. Harbor porpoise densities recorded during industry operations in the fall months of 2006-2010 were slightly lower and ranged from 0.0/km^2 to 0.0044/km^2 with a maximum 95 percent CI of 0.0275/km^2. The average of those years (0.0021/km^2) was again used as the average density estimate and the high value (0.0044/km^2) was used as the maximum estimate (Table 6-2).

Table 6-2 Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska for the Fall (September–October) Period

	Open Water		Ice Margin	
Species	**Average Density (# / km²)**	**Maximum Density (# / km²)**	**Average Density (# / km²)**	**Maximum Density (# / km²)**
Odontocetes				
Monodontidae				
Beluga	0.0031	0.0053	0.0124	0.0212
Narwhal	0.0000	0.0000	0.0000	0.0001
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0021	0.0044	0.0021	0.0044
Mysticetes				
Bowhead whale	0.0552	0.1320	0.1104	0.2640
Fin whale	0.0001	0.0004	0.0001	0.0004
Gray whale	0.0118	0.0248	0.0118	0.0248
Humpback whale	0.0001	0.0004	0.0001	0.0004
Minke whale	0.0003	0.0006	0.0003	0.0006
Pinnipeds				
Bearded seal	0.0107	0.0203	0.0142	0.0270
Ribbon seal[1]	0.0007	0.0028	0.0007	0.0028
Ringed seal	0.2458	0.4070	0.3277	0.5427
Spotted seal	0.0049	0.0081	0.0065	0.0108

[1]On July 25, 2014 the U.S. 9th district court vacated the listing rule with respect to the Beringia bearded seal DPS and remanded the rule to NMFS to correct the deficiencies identified in the opinion. The Beringia DPS is not listed, but the listing is still in effect for the Okhotsk DPS (which is located in the Okhotsk Sea off the coast of Russia)

*Species listed under the US ESA as Endangered or Threatened are in italics.

(e) Other Whales

The remaining five cetacean species that could be encountered in the Chukchi Sea during Shell's planned exploration drilling program include the humpback whale, killer whale, minke whale, fin whale, and narwhal. Although there is evidence of the occasional occurrence of these five cetacean species in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the planned exploration drilling program and therefore minimum densities have been assigned to these species (Tables 6-1 and 6-2). Clarke et al. (2011, 2013) and Hartin et al. (2013) reported humpback whale sightings; George and Suydam (1998) reported killer whales; Brueggeman et al. (1990), Hartin et al. (2013), Clarke et al. (2012, 2013), and Reider et al. (2013) reported minke whales; and Clarke et al. (2011, 2013) and Hartin et al. (2013) reported fin whales. With regard to humpback and fin whales, Allen and Angliss(2014) recently concluded these whales occur in very low numbers in the project area, but may be regular visitors. Narwhal sightings in the Chukchi Sea have not been reported in recent literature, but subsistence hunters occasionally report observations near Barrow, and Reeves et al. (2002) indicated a small number of extralimital sightings in the Chukchi Sea.

Of these uncommon cetacean species, minke whale has the potential to be the most common based on recent industry surveys. Reider et al. (2013) reported 13 minke whale sightings in the Chukchi Sea in

2013 during Shell's marine survey program. All but one minke whale sighting in 2013; however, were observed in nearshore areas despite only minimal monitoring effort in nearshore areas compared to more offshore locations near the Burger prospect (Reider et al. 2013).

Pinnipeds

Three species of pinnipeds under NMFS jurisdiction are likely to be encountered in the Chukchi Sea during Shell's planned exploration drilling program: ringed seal, bearded seal, and spotted seal. Ringed and bearded seals are associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) for ringed and bearded seals during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice. However, satellite tagging has shown that they sometimes undertake long excursions into offshore waters during summer (Lowry et al. 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Patterson et al. 2007, Hartin et al. 2013).

(a) Ringed and Bearded Seals

Ringed seal and bearded seals "average" and "maximum" summer ice-margin densities (Table 6-1) were available in Bengtson et al. (2005) from spring surveys in the offshore pack ice zone (zone 12P) of the northern Chukchi Sea. However, corrections for bearded seal availability, *g(0)*, based on haulout and diving patterns were not available. Densities of ringed and bearded seals in open water are expected to be somewhat lower in the summer when preferred pack ice habitat may still be present in the Chukchi Sea. Average and maximum open-water densities have been estimated as 3/4 of the ice margin densities during both seasons for both species. The fall density of ringed seals in the offshore Chukchi Sea has been estimated as 2/3 the summer densities because ringed seals begin to reoccupy nearshore fast ice areas as it forms in the fall (Table 6-2). Bearded seals may also begin to leave the Chukchi Sea in the fall, but less is known about their movement patterns so fall densities were left unchanged from summer densities. For comparison, the ringed seal density estimates calculated from data collected during summer 2006-2010 industry operations ranged from $0.0138/km^2$ to $0.0464/km^2$ with a maximum 95 percent CI of $0.1581/km^2$ (Hartin et al. 2013). These estimates are lower than those made by Bengtson et al. (2005), which is not surprising given the different survey methods and timing.

(b) Spotted Seals

Little information on spotted seal densities in offshore areas of the Chukchi Sea is available. Spotted seal densities in the summer were estimated by multiplying the ringed seal densities by 0.02. This was based on the ratio of the estimated Chukchi populations of the two species (Table 4-1). Chukchi Sea spotted seal abundance was estimated by assuming that 8 percent of the Alaskan population of spotted seals is present in the Chukchi Sea during the summer and fall (Rugh et al. 1997), the Alaskan population of spotted seals is 59,214 (Allen and Angliss 2014), and that the population of ringed seals in the Alaskan Chukchi Sea is ~208,000 animals (Bengtson et al. 2005). In the fall, spotted seals show increased use of coastal haulouts so densities were estimated to be 2/3 of the summer densities.

(c) Ribbon Seals

Four ribbon seal sightings were reported during industry vessel operations in the Chukchi Sea in 2006-2010 (Hartin et al. 2013). The resulting density estimate of $0.0007/km^2$ was used as the average density and 4 times that was used as the maximum for both seasons and habitat zones.

Individual Sound Sources and Level B Radii

As described in earlier sections, the assumed start date of Shell's exploration drilling program in the Chukchi Sea using the drilling units *Discoverer* and *Polar Pioneer* with associated support vessels is 4 July. Shell may conduct exploration drilling activities at up to four drill sites at the prospect known as Burger. Drilling activities are expected to be conducted through on or about 31 October 2015.

Previous IHA applications for offshore Arctic exploration programs estimated areas potentially ensonified to ≥120 or ≥160 dB re 1µPa rms independently for each continuous or pulsed sound source, respectively (e.g., drilling, ZVSP, etc.). The primary method used in this IHA application for estimating areas ensonified to continuous sound levels ≥120 dB re 1µPa rms by drilling-related activities involved sound propagation modeling of a variety of scenarios consisting of multiple, concurrently-operating sound sources. These "activity scenarios" consider additive acoustic effects from multiple sound sources at nearby locations, and more closely capture the nature of a dynamic acoustic environment where numerous activities are taking place simultaneously. The area ensonified to ≥160 dB re 1µPa rms from ZVSP, a pulsed sound source, was treated independently from the activity scenarios for continuous sound sources.

The continuous sound sources used for sound propagation modeling of activity scenarios included 1) *drilling unit and drilling sounds*, 2) *supply and drilling support vessels using DP when tending to a drilling unit,* 3) *MLC construction,* 4) *anchor handling in support of mooring a drilling unit,* and 5) *ice management activities*. The information used to generate sound level characteristics for each continuous sound source is summarized below to provide background on the model inputs. A "safety factor" of 1.3 dB re 1µPa rms was added to the source level for each sound source prior to modeling activity scenarios to account for variability across the project area associated with received levels at different depths, geoacoustical properties, and sound-speed profiles. The addition of the 1.3 dB re 1 µPa rms safety factor to source levels resulted in an approximate 20 percent increase in the distance to the 120 dB re 1µPa rms threshold for each continuous source.

Table 6-3 summarizes the 120 dB re 1 µPa rms radii for individual sound sources, both the "original" radii as measured in the field, and the "adjusted" values that were calculated by adding the "safety factor" of 1.3 dB re 1 µPa rms to each source. The adjusted source levels were then used in sound propagation modeling of activity scenarios to estimate ensonified areas and associated marine mammal exposure estimates. Additional details for each of the continuous sound sources presented in Table 6-3 are discussed below.

The pulsed sound sources used for sound propagation modeling of activity scenarios consisted of two small airgun arrays proposed for ZVSP activities. All possible array configurations and operating depths were modeled to identify the arrangement with the greatest sound propagation characteristics. The resulting ≥160 dB re 1µPa rms radius was multiplied by 1.5 as a conservative measure prior to estimating exposed areas, which is discussed in greater detail below.

Table 6-3 Measured and Adjusted 120 dB re 1 µPa rms Radii for Individual, Continuous Sound Sources (Adjusted Radii Were Used for Sound Propagation Modeling of Activity Scenarios)

	Radii of 120 dB re 1 µPa (rms) Isopleth (meters)	
Activity / Continuous Sound Source	**Original Measurement**	**With 1.3 dB re 1 µPa Added to Source Level**
Drilling at 1 Site	1,500	1,800
Vessel in DP	4,500	5,500
Mudline Cellar Construction at 1 Site	8,200	9,300
Anchor Handling at 1 Site (Assumed to be 2 Vessels)**	19,000	22,000
Single Vessel Ice Management	9,600	11,000

**The measurement of anchor handling in 2012 involved a single vessel. Anchor handling in 2015 is likely to involve two concurrently-operating vessels at a single site. To account for this, the 2012 anchor handling measurement was treated as two separate but concurrently-operating sound sources and modeled for subsequent application in activity scenarios involving anchor handling.

Drilling Units and Drilling Sounds

Prior to 2012, sounds from the *Discoverer* had not been measured in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned drilling locations in the Chukchi and Beaufort seas (Warner and Hannay 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship, but were generally between 177 and 185 dB re 1 µPa 1 m rms (Austin and Warner 2010). Propagation modeling at the Burger Prospect resulted in an estimated distance of 1.31 km to the point at which drilling sounds would likely fall below 120 dB re 1µPa rms. In the 2012 IHA application, the modeled 1.31 km distance was multiplied by 1.5 as a precautionary measure (equaling 1.97 km) before calculating the total area that may be ensonified to continuous sounds ≥120 dB re 1 µPa rms by the *Discoverer* at each drill site on the Burger Prospect.

During 2012 exploration drilling activities, measurements of sounds produced by the *Discoverer* were made on the Burger prospect. The recorded data show a number of tonal components likely produced by vibrations from rotating machinery. Most of the acoustic energy was contained in the 100-1000 Hertz (Hz) and 1-10 kHz frequency bands, both of which typically were at levels just below 120 dB re 1 µPa rms. When no other vessels were present near the *Discoverer* and drilling was occurring, broadband sound levels fell below 120 dB re 1 µPa rms at 1.5 km (Austin et al. 2013). This measurement of the *Discoverer* in 2012, plus addition of the 1.3 dB re 1 µPa rms safety factor, was used for sound propagation modeling of all activity scenarios involving the *Discoverer.*

Measured sound levels for the *Polar Pioneer* while drilling were not available, therefore the ≥ 120 dB re 1 µPa sound footprint was estimated using JASCO Applied Science's Marine Operations Noise Model (MONM). An average source level for the *Polar Pioneer* was derived from a number of acoustic measurements of comparable semi-submersible drill units. Taken into account were reported sound levels from the drilling units *Ocean Bounty* (Gales 1982), SEDCO 708 (Greene 1986), and *Ocean General* (McCauley 1998). One-third-octave band received sound levels were extracted from these reports and were back-propagated to a range of 1 m. The resulting 1/3-octave source levels were averaged to provide a distribution that was input to MONM as a surrogate for the *Polar Pioneer*. The model yielded a propagation range of 350 m for rms sound pressure levels of 120 dB re 1 µPa rms for the *Polar Pioneer* while drilling at the Burger Prospect. This estimate of the *Polar Pioneer*, plus the safety factor, was used for sound propagation modeling of activity scenarios involving the *Polar Pioneer.*

Supply and Drilling Support Vessels using Dynamic Positioning

When support vessels arrive to transfer materials to or from drilling units, or to conduct other drilling support activities, DP thrusters are commonly used to keep the vessel stationary next to the drilling unit or on location.

Acoustic measurements of the *Nordica* in DP mode while supporting Shell's 2012 drilling operation in the Chukchi Sea were made from multiple recorders deployed to monitor sounds from the overall drilling operation. Distances to these recorders ranged from 1.3 km to 7.9 km and maximum sound pressure levels ranged from 112.7 dB re 1 µPa rms to 129.9 dB re 1 µPa rms. Analysis of the data indicates the maximum 120 dB re 1 µPa rms distance was approximately 4 km from the vessel. In 2011, Statoil conducted geotechnical coring operations in the Chukchi Sea using the vessel *Fugro Synergy*. Measurements were taken using bottom founded recorders at 50 m, 100 m, and 1 km away from the borehole while the vessel was in DP mode (Warner and McCrodan 2011). Sound levels measured at the recorder 1 km away ranged from 119 dB re 1 µPa rms to 129 dB re 1 µPa rms. A propagation curve fit equation applied to the data and encompassing 90 percent of all measured values during the period of strongest sound emissions provides an estimate that sound levels would drop below 120 dB re 1 µPa rms at 2.3 km.

More recently, the *Nordica* was operated by Shell in 2013 at the Burger Prospect to conduct well site maintenance activities. The vessel operated in DP much of the time and was measured during these periods by a line of hydrophones moored to the seafloor at distances of 0.5, 1, 2, 4, and 8 km from the well (JASCO and Greeneridge 2014). Results indicated a strong relationship between sound levels received at the hydrophones and the orientation of the vessel relative to the linear array of recorders. Measured distances to the 120 dB re 1 µPa rms threshold were nearly three times greater when the vessel was perpendicular to the line of acoustic recorders compared to when it was oriented nearly parallel along the same line as the recorders. The 90^{th} percentile distance to the 120 dB re 1 µPa rms threshold for periods when the Nordica was broadside to the line of recorders was 4.5 km (JASCO and Greeneridge 2014). This measurement of the *Nordica*, plus the 1.3 dB re 1 µPa rms safety factor, was used for sound propagation modeling of activity scenarios involving supply and drilling support vessels in DP.

Mudline Cellar Construction

A MLC is a relatively large-diameter hole constructed so that equipment at the top of the well can be installed below the level of the seabed, hence below the greatest depth of a potential ice keel gouge. The construction of this hole during Shell's 2012 exploration drilling program in the Chukchi Sea generated broadband sounds that were recorded by hydrophones moored to the seafloor at distances of 1, 2, 4, and 8 km. JASCO (2014) calculated that these sounds diminished below the 120 dB re 1 µPa rms threshold at 8.2 km from the drill site. This 2012 *Discoverer* MLC measurement (JASCO and Greeneridge 2014), plus the safety factor, was used for sound propagation modeling of all activity scenarios involving construction of MLCs.

Anchor Handling

The *Discoverer* drillship was held in place at the Chukchi Sea well site in 2012 by connecting to eight large anchors that were placed and set into the seabed prior to the arrival of the *Discoverer*. The setting of these anchors, as well as the process of connecting the *Discoverer* to the anchors, generated sound levels above those of drilling alone.

JASCO (2014) measured sound levels produced by the *Tor Viking* during activities associated with anchor handling in the Chukchi Sea during Shell's 2012 exploration drilling program at Burger. Distance to the 120 dB re 1 µPa rms distance during these activities was estimated to be 14 km (JASCO and Greeneridge 2014). This measurement; however, involved only a single vessel, whereas anchor handling in 2015 may involve two vessels working in tandem. To account for this, the 2012 anchor handling measurement (JASCO and Greeneridge 2014) was scaled upward using the safety factor and treated as two separate but concurrently-operating sound sources for sound propagation modeling of activity scenarios involving anchor handling.

In 2015, anchor handling activities are expected to occur whenever a drilling unit moves on to or off a drill site. Each anchor handling event is expected to last several days.

Ice Management Activities

Measurements of the icebreaking supply ship Robert Lemeur pushing and breaking ice during exploration drilling operations in the Beaufort Sea in 1986 resulted in an estimated broadband source level of 193 dB re 1 µPa·m (Greene 1987a; Richardson et al. 1995a). Measurements of the icebreaking sounds were made at five different distances and those were used to generate a propagation loss equation (RL)=141.4–1.65R–10Log(R) where R is range in kilometers (Greene 1987a); converting R to meters results in the following equation: R=171.4–10log(R)–0.00165R]. Using this equation, the estimated distance to the 120 dB re 1 µPa rms threshold level for continuous sounds from icebreaking was 7.63 km. These measurements of the Robert Lemeur were taken in the Beaufort Sea under presumably similar conditions as would be encountered in the Chukchi Sea in 2015.

During exploration drilling operations on the Burger Prospect in 2012, encroachment of sea ice required the *Discoverer* to temporarily depart the drill site. While it was standing by to the south, ice management vessels remained at the drill site to protect buoys that were attached to the anchors. Sounds produced by vessels managing the ice were recorded and the distance to the 120 dB re 1 µPa rms isopleth was calculated to occur at 9.6 km (JASCO and Greeneridge 2014).

Measurements of ice management sounds near Burger in 2012 involved only a single vessel, the *Tor Viking II* (JASCO and Greeneridge 2014). Operations in 2015 could involve up to four ice management vessels operating at one time, split between two drill sites. To account for this difference, the 2012 measurement of ice management was scaled upward using the 1.3 dB re 1 µPa rms safety factor and treated as four separate but concurrently-operating sound sources for sound propagation modeling. A second ice management activity scenario was modeled to estimate areas exposed to ≥120 dB re 1 µPa rms when only two vessels were managing ice at a given time.

Ice management could occur at any time in the vicinity of the Burger Prospect during Shell's planned 2015 exploration drilling program. The need to manage ice; however, is expected to be greater in summer compared to fall when the Burger Prospect becomes sea-ice free as in most years.

ZVSP Activities

Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in^3 (2,458 cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4,097 cu cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Sound footprints for each of the two proposed ZVSP airgun array configurations were estimated using JASCO Applied Sciences' MONM. The model results were maximized over all water depths from 9.8 to 23 ft. (3 to 7 m) to yield precautionary sound level isopleths as a function of range and direction from the source. The 450 in^3 airgun array at a source depth of 7 m yielded the maximum ranges to the ≥190, ≥180, and ≥160 dB re 1 µPa rms isopleths.

There are two reasons that the radii for the 450 in^3 airgun array are larger than those for the 500 in^3 array. First, the sound energy does not scale linearly with the airgun volume, rather it is proportional to the cube root of the volume. Thus, the total sound energy from three airguns is larger than the total energy from two airguns, even though the total volume is smaller. Second, larger volume airguns emit more low-frequency sound energy than smaller volume airguns, and low-frequency airgun sound energy is strongly attenuated by interaction with the surface reflection. Thus, the sound energy for the larger-volume array experiences more reduction and results in shorter sound threshold radii.

The estimated 95^{th} percentile distances to the following thresholds for the 450 in^3 airgun array were: ≥190 dB re 1 μPa rms = 170 m, ≥180 dB re 1 μPa rms = 920 m, and ≥160 dB re 1 μPa rms = 7,970 m. The ≥160 dB re 1 μPa rms distance was multiplied by 1.5 for a distance of 11,960 m. This radius was used for estimating areas ensonified by pulsed sounds to ≥160 dB re 1 μPa rms during a single ZVSP survey. ZVSP surveys may occur at up to two different drill sites during Shell's planned 2015 exploration drilling program in the Chukchi Sea.

Total Estimated Areas Ensonified by to Continuous or Nonpulsed Sounds to ≥120 dB re 1μPa rms and Pulsed Sounds ≥160 dB re 1μPa rms

As noted above, previous IHA applications for Arctic offshore exploration programs estimated areas potentially ensonified to continuous sound levels ≥120 dB re 1μPa rms independently for each sound source. This method was appropriate for assessing a small number of continuous sound sources that did not consistently overlap in time and space. However, many of the continuous sound sources described above will operate concurrently at one or more nearby locations in 2015 during Shell’s planned exploration drilling program in the Chukchi Sea. It is therefore appropriate to consider the concurrent operation of numerous sound sources and the additive acoustic effects from combined sound fields when estimating areas potentially exposed to levels ≥120 dB re 1 μPa rms.

A wide range of potential “activity scenarios” was derived from a realistic operational timeline by considering the various combinations of different continuous sound sources that may operate at the same time at one or more locations. The total number of possible activity combinations from all sources at up to four different drill sites would not be practical to assess or present in a meaningful way. Additionally, combinations such as concurrent drilling and anchor handling in close proximity do not add meaning to the analysis given the negligible contribution of drilling sounds to the total area ensonified by such a scenario. For these reasons, various combinations of similar activities were grouped into representative activity scenarios shown in Table 6-4. Ensonified areas for these representative activity scenarios were estimated through sound propagation modeling. Activity scenarios were modeled for different drill site combinations and, as a conservative measure, the locations corresponding to the largest ensonified area were chosen to represent the given activity scenario. In other words, by binning all potential scenarios into the most conservative representative scenario, the largest possible ensonified areas for all activities were identified for analysis. A total of nine representative activity scenarios were modeled to estimate areas exposed to continuous sounds ≥120 dB re 1 μPa rms for Shell’s planned 2015 exploration drilling program in the Chukchi Sea (Table 6-4). A tenth scenario was included for the ZVSP activities.

Table 6-4 Sound Propagation Modeling Results of Representative Drilling Related Activity Scenarios and Estimates of the Total Area Potentially Ensonified above Threshold Levels at the Burger Prospect in the Chukchi Sea, Alaska During the Planned 2015 Exploration Drilling Program

Activity Scenario Number	Activity Scenario Description	Threshold Level (dB re 1 µPa)	Area Potentially Ensonified (km^2)	
			Summer	Fall
1	Drilling at 1 site	120 dB	10.2	10.2
2	Drilling and DP Vessel at 1 site	120 dB	111.8	111.8
3	Drilling and DP Vessel (1 site) + Drilling and DP Vessel (2^{nd} site)	120 dB	295.5	295.5
4	Mudline Cellar Construction at 2 different sites	120 dB	575.5	575.5
5	Anchor Handling at 1 site	120 dB	1,534.9	1,534.9
6	Drilling and DP Vessel at 1 site + Anchor Handling at 2^{nd} site	120 dB	1,759.2	1,759.2
7	Mudline Cellar Construction at 2 different sites + Anchor Handling at 3^{rd} site	120 dB	2,046.3	2,046.3
8	Two-vessel Ice Management	120 dB	937.4	937.4
9	Four-vessel Ice Management	120 dB	1,926.0	1,926.0
10	ZVSP at 2 different sites	160 dB	0.0	898.0

As noted above, sound propagation modelling of ensonified areas involved multiple sources that would be operating at the same time. Such concurrent operations result in additive acoustic effects in areas where there is overlap in the sound fields produced by the equipment in use. Therefore, the ensonified areas associated with each of these scenarios represents the additive acoustic effects from concurrently-operating, continuous sound sources at different locations, and they result in irregular or non-circular ensonified areas when activities are occurring at different locations (activity scenarios 3-4 and 6-9; Table 6-4). Unlike a circular acoustic footprint from a single continuous sound source or sources at a single location, these irregular areas do not have defined radii.

Figures 6-1 through 6-4 depict estimated areas ensonified by continuous sound levels ≥120 dB re 1 µPa rms for a representative sample of activity scenarios (1, 3, 7, and 8 from Table 6-4). Sound propagation modeling of each activity scenario was performed by incorporating each of the respective individual, continuous sound sources using measured source levels, and then again after adding a 1.3 dB re 1 µPa rms "safety factor" to each source level. The resulting ensonified areas from each method are shown for activity scenarios 1, 3, 7, and 8 in Figures 6-1 through 6-4. However, only the larger areas resulting from the application of the "safety factor" were used to estimate marine mammal exposures.

The areas potentially ensonified by each activity scenario assume all sound sources identified for that scenario would be operating concurrently. Generally each scenario consists of one to three sources; scenarios 3 and 9 are the exceptions, each of which includes four sources (Table 6-4). This approach was an attempt to move away from assessing ensonified areas stemming from different sources in isolation, or independently one-by-one, and instead begin assessing the acoustic environment more realistically as an aggregate of multiple sound sources operating concurrently. This approach to sound propagation modeling allows for the consideration of additive acoustic effects from overlapping sound fields produced by numerous, continuous sound sources (Figures 6-2 through 6-3). Ultimately, this method attempts to more accurately simulate the underwater acoustic environment resulting from an exploratory drilling program such as that proposed by Shell in 2015.

Figure 6-1 Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 1, Drilling at a Single Site. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to the Source

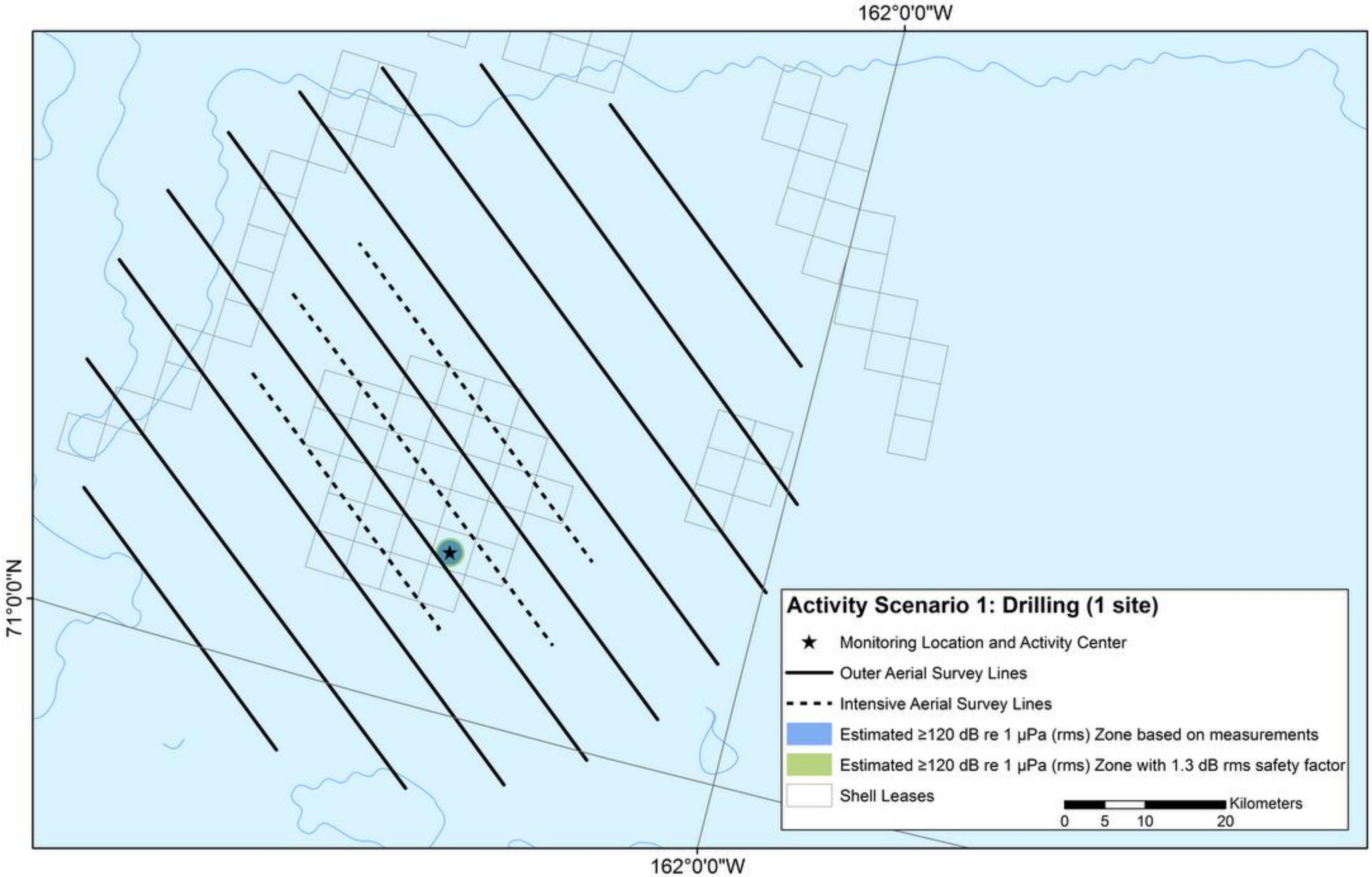


Figure 6-2 Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 3, Concurrent Drilling with an Adjacent Support Vessel in DP at Two Sites. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source

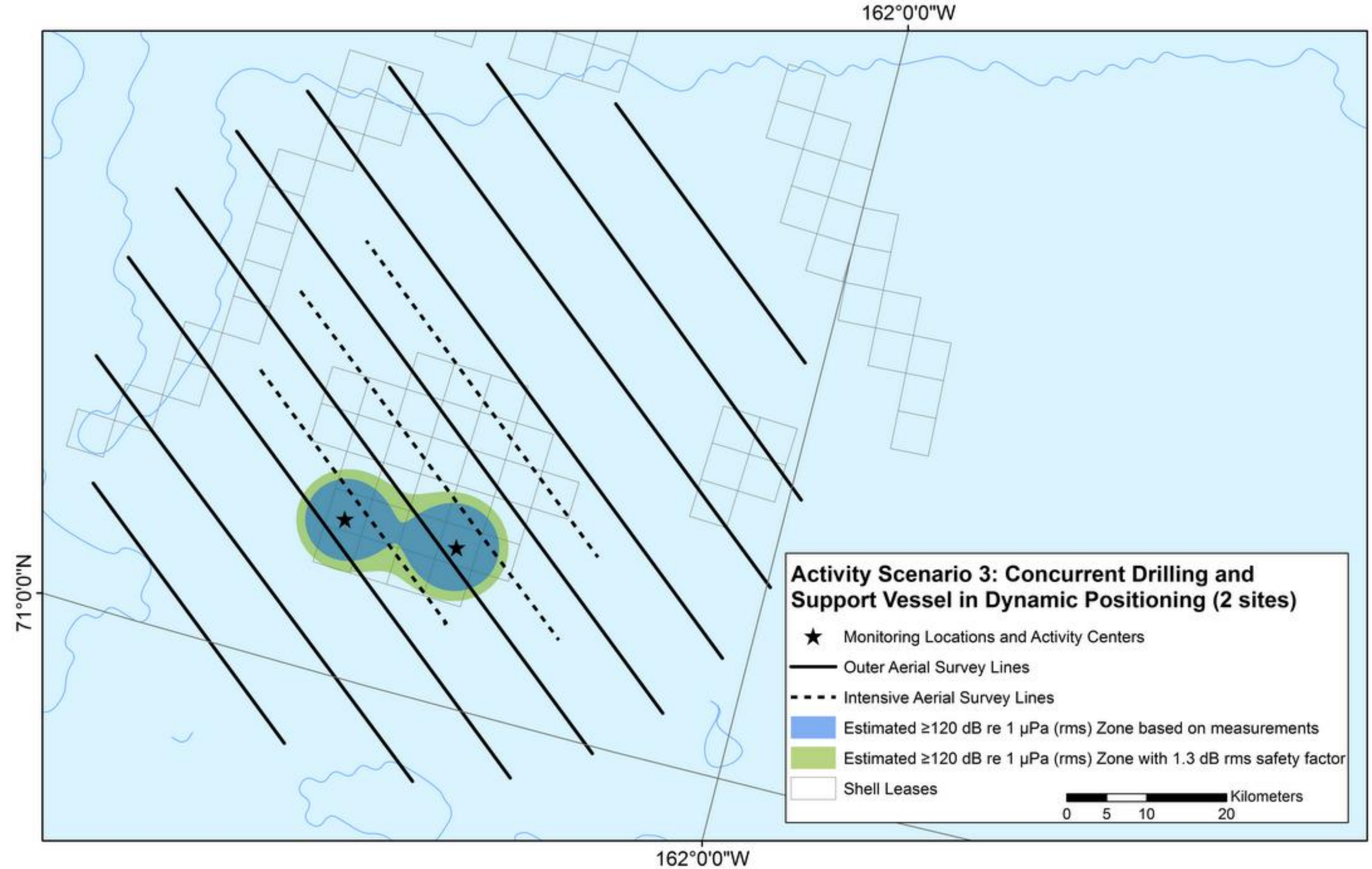


Figure 6-3 Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 µPa rms from Activity Scenario 7, Concurrent Mudline Cellar Construction at Two Sites and Anchor Handling at a Third Site. Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 µPa rms Safety Factor to each Source

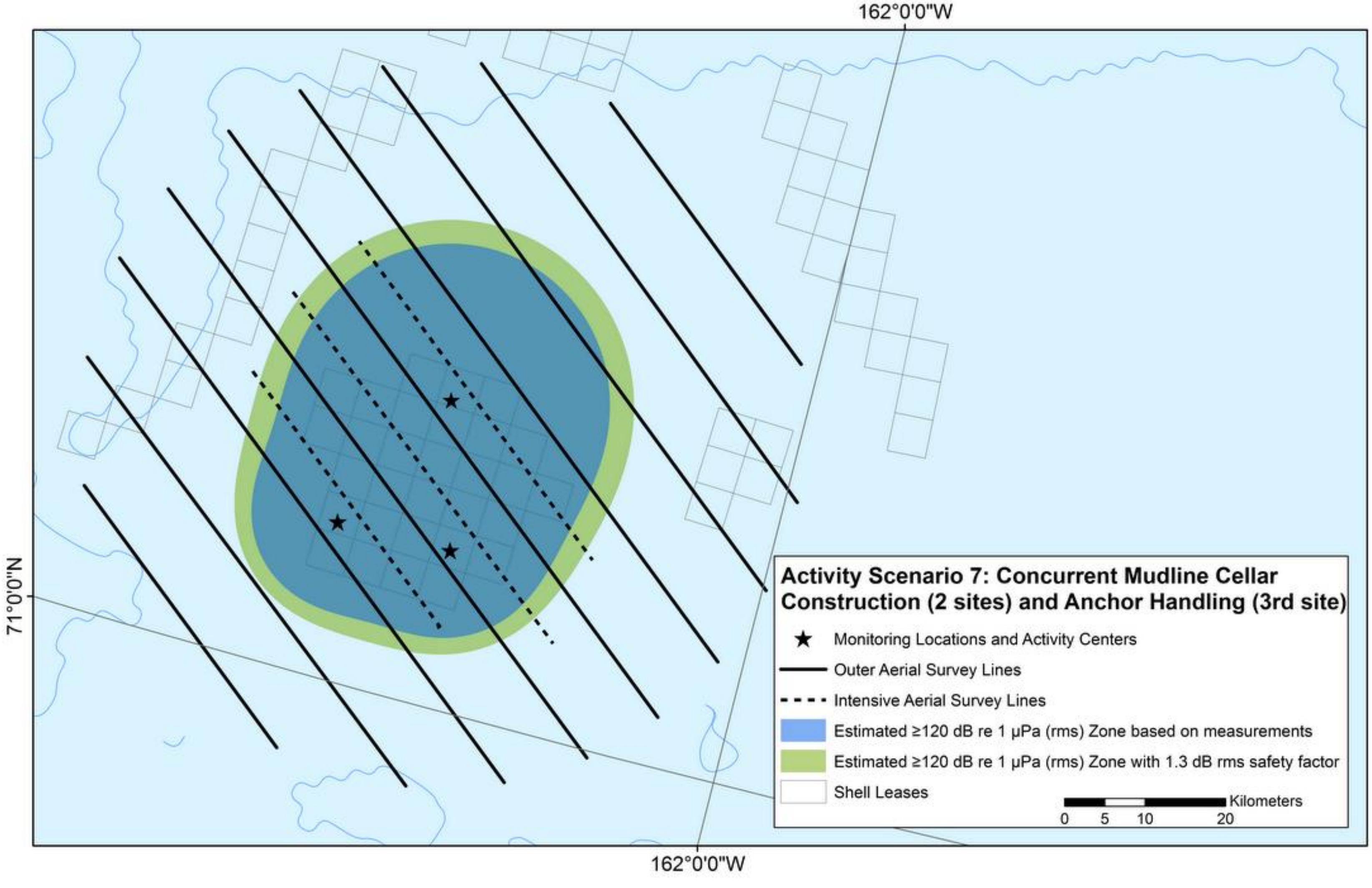
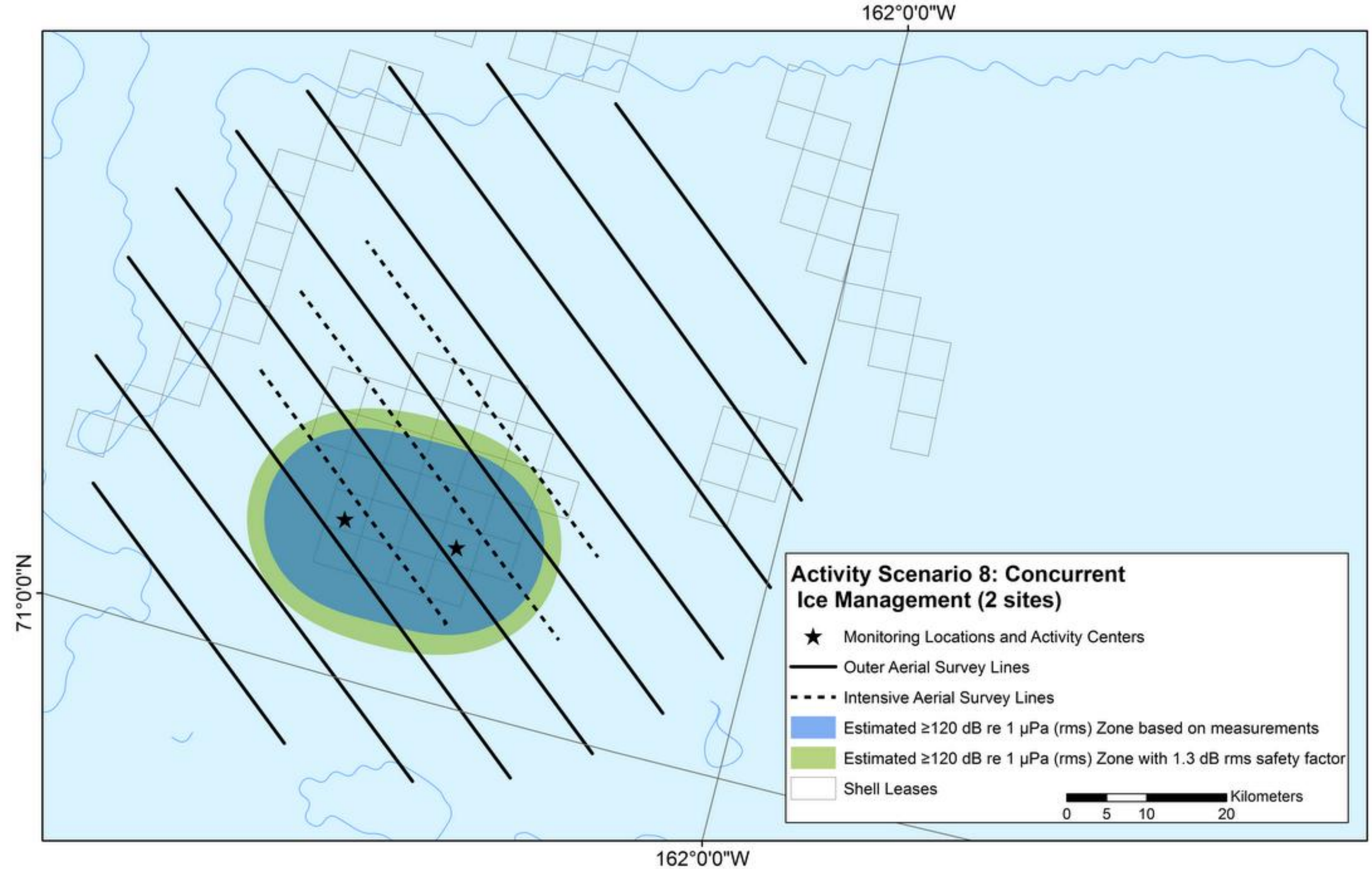


Figure 6-4 Estimated Areas Ensonified by Continuous Sound Levels ≥120 dB re 1 μPa rms from Activity Scenario 8, Concurrent Ice Management at Two Sites (Offset 500 Meters to the NE of Each Well). Aerial Survey Transects are also Shown. The Smaller Area (Blue) Reflects the Measured Source Value and the Larger Area (Green) Accounts for Addition of the 1.3 dB re 1 μPa rms Safety Factor to each Source



The largest area estimated to be ensonified by continuous sounds of ≥120 dB re 1 µPa rms from a single activity scenario was 2,046.3 km^2 and resulted from concurrent MLC construction at two different sites and anchor handling at a third site (activity scenario 7; Table 6-4; Figure 6-3). The smallest area estimated to be ensonified by continuous sound levels ≥ 120 dB re 1 µPa rms was 10.3 km^2, which represented drilling alone at a single site by the *Discoverer* (activity scenario 1; Table 6-4; Figure 6-1). The *Discoverer* was used as the sound source for the single site drilling-only scenario as a conservative measure because it is expected to be the louder of the two drilling units. The specific estimated sound source levels for the *Discoverer* and the *Polar Pioneer* were used for the modeling of activity scenarios that involved concurrent drilling at two different drill sites. In general, scenarios that involved anchor handling and/or MLC construction resulted in the largest estimated areas that would be ensonified to levels ≥120 dB re 1 µPa rms (activity scenarios 4-7; Table 6-4; Figures 6-3 and 6-4). Activity scenarios that involved drilling and/or DP vessel operations produced the smallest acoustic footprints (activity scenarios 1-3; Table 6-4; Figures 6-1 and 6-2).

It is possible that ice management and drilling activities could have overlapping acoustic footprints; however, it is difficult to meaningfully quantify the countless ways in which this could occur due to the temporal and spatial variability of ice conditions. It is also likely that ice management will occur at distances from the drill sites that would result in independent, non-overlapping acoustic footprints with respect to continuous sound sources operating at or near exploration drill sites. For these reasons, concurrent ice management activity scenarios were modeled separately from non-ice management scenarios, and results from each were summed together below to conservatively estimate the maximum total area ensonified to continuous sound levels ≥120 dB re 1 µPa rms.

The two scenarios that were modeled to estimate areas ensonified by continuous sounds ≥120 dB re 1 µPa rms from ice management involved either two or four vessels engaged in concurrent operations. The two-vessel scenario assumed a single ice management vessel positioned 500 m to the northeast of two different drill sites. The four-vessel scenario assumed ice management associated with two different drill sites with one vessel located 500 m to the northeast of each site and a second vessel positioned 2 km to the northeast of each site. The estimated areas ensonified by continuous sounds ≥ 120 dB re 1 µPa rms from two- and four-vessel ice management activities were 937.4 and 2,046.3 km^2, respectively (activity scenarios 8 and 9; Table 6-4).

No ZVSP surveys are expected to occur in the summer. Following the completion of drilling at each of the first two exploration wells in fall of 2015, a ZVSP survey will be conducted at each site. This would result in exposure of twice the area from a single ZVSP survey to pulsed sound levels ≥160 dB re 1 µPa rms, or 898 km^2 (activity scenario 10; Table 6.4).

Potential Number of "Takes by Harassment"

This section provides estimates of the number of individuals potentially exposed to continuous sound levels ≥120 dB re 1 µPa rms from exploration drilling related activities and pulsed sound levels ≥160 dB re 1 µPa rms by ZVSP activities. The estimates are based on a consideration of the number of marine mammals that might be affected by operations in the Chukchi Sea during 2015 and the anticipated area exposed to those sound levels.

Previous IHA applications for this region have typically estimated the total maximum area ensonified above threshold levels during each season and multiplied the areas by their respective seasonal marine mammal densities. This approach overestimated the area that would be ensonified on any single day within each season, and it did not account for marine mammal movements. A similar approach has been included in this application for comparison with a revised method that takes the turnover of individual marine mammals in ensonified areas into account. The revised method also assumes a degree of avoidance of ensonified areas by bowhead whales. Each method and the corresponding exposure estimates are presented below. To account for different densities in different habitats, we have assumed that more ice is likely to be present in the area of operations during the July–August period than in the September–October period, so summer ice-margin densities have been applied to 50 percent of the area that may be exposed to sounds from exploration drilling activities in those months. Open water densities in the summer were applied to the remaining 50 percent of the area.

Less ice is likely to be present during the September–October period than in the July–August period, so fall ice-margin densities have been applied to only 20 percent of the area that may be exposed to sounds from exploration drilling activities in those months. Fall open-water densities were applied to the remaining 80 percent of the area. Since icebreaking activities would only occur within ice-margin habitat, the entire area potentially ensonified by icebreaking activities has been multiplied by the ice-margin densities in both seasons.

Exposure Estimates Without Turnover of Individuals

The following method does not account for movement of individuals into and out of ensonified areas (i.e., turnover). The number of individuals of each species potentially exposed to received levels of continuous drilling related sounds ≥120 dB re 1 µPa rms or to pulsed airguns sounds ≥160 dB re 1 µPa rms within each season (summer and fall) and habitat zone was estimated by multiplying the anticipated area ensonified to the threshold level(s) in each season (summer and fall) and habitat zone to which that density applies, by the expected species density. The numbers of individuals potentially exposed were then summed for each species across the two seasons and habitat zones.

To estimate the maximum total area that might be ensonified by continuous sounds ≥120 dB re 1 µPa rms in either summer or fall during Shell's 2015 exploration drilling program in the Chukchi Sea, the largest ensonified area estimated for the non-ice management scenarios (two MLC constructions plus anchor handling) was added to the ensonified area estimated for the four-vessel ice management scenario. The sum of areas ensonified to ≥120 dB re 1 µPa rms from these two scenarios results in a total area of 3,972.3 km^2 (activity scenarios 7 and 9; Table 6-4). These activities generate louder continuous sounds than drilling; however, they will occur for only brief periods relative to the entire exploration drilling period. Regardless of the short duration of these louder sounds compared to the overall drilling period, this area has been used to estimate potential exposures of marine mammals above Level B threshold levels on a seasonal basis (both ≥120 dB re 1 µPa rms for continuous sounds and ≥160 dB re 1 µPa rms for pulsed sounds).

Estimates of the average and maximum number of individual marine mammals that may be exposed to sounds above Level B thresholds are shown by season and habitat in Table 6-5. These estimates represent the ensonified areas from activity scenario 7 (concurrent construction of two MLCs and anchor handling) and activity scenario 9 (four-vessel ice management) for each season multiplied by the marine mammal densities in those seasons. This method was used in previous IHA applications for exploration drilling programs in Alaska.

Table 6-5 The Number of Potential Exposures of Marine Mammals to Received Sound Levels above Level B Thresholds in Summer (July–August) and Fall (September–October) in the Chukchi Sea, Alaska, 2015. These Estimates do not Account for Animal Movements into or out of the Ensonified Areas During Exploration Program Activities at Each Drill Site. All Fractional Values have been Rounded to the Nearest Whole Number. Totals Reflect the Sum of Fractional Values, Not the Sum of Rounded Values

	Total Number of Individuals Potentially Exposed to Sounds Continuous Sounds ≥120 dB re 1 μPa (rms) or Pulsed Sounds ≥160 dB e 1 μPa (rms)													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	2	5	28	58	31	63	5	9	29	50	34	58	65	121
Narwhal	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Delphinidae														
Killer whale	0	0	0	1	0	2	0	1	0	1	0	2	1	5
Phocoenidae														
Harbor porpoise	2	3	6	9	9	12	3	7	5	10	8	17	17	29
Mysticetes														
Bowhead whale	2	7	6	20	8	27	90	216	258	617	348	833	356	860
Fin whale	0	0	0	1	0	2	0	1	0	1	0	2	1	5
Gray whale	26	27	75	79	100	106	19	41	28	58	47	99	147	205
Humpback whale	0	0	0	1	0	2	0	1	0	1	0	2	1	5
Minke whale	0	0	0	1	0	2	0	1	0	1	0	2	3	8
Pinnipeds														
Bearded seal	11	21	42	80	53	100	17	33	33	63	51	96	103	197
Ribbon seal	1	3	2	8	3	11	1	5	2	7	3	11	6	22
Ringed seal	375	622	1442	2389	1818	3010	402	666	765	1267	1168	1934	2985	4944
Spotted seal	8	12	29	48	36	60	8	13	15	25	23	38	60	99

Exposure Estimates Including Turnover of Individuals

The following method is fundamentally identical to the method above (i.e., ensonified area X animal density), however, it incorporates additional considerations to account for animal movements and variation in the size of ensonified areas for each day across the operation. This revised approach assumed the entire population of marine mammals within the area ensonified to sounds above the Level B thresholds for continuous and pulsed sounds would be different every day during drilling and related support activities. This method also allowed for the different ensonified areas corresponding to the activity scenarios in Table 6-4 to be changed on a daily basis to reflect the anticipated operational timeline. To do this, the numbers of days within each season were split between the various activity scenarios and summed within the two seasons (Table 6-6).

Multiple activity scenarios may occur on the same day, so scenarios that are likely to produce louder sounds and ensonified larger areas to sounds above Level B thresholds have been used on those days in order to provide a conservative estimate. Activity days for ice management and ZVSP were assigned in addition to the number of days allocated to the other activity scenarios within each season. Ice management could occur at distances far enough from the drill sites to produce independent, non-overlapping acoustic footprints with respect to the other continuous sound sources operating at or near exploration drill sites. Despite the likelihood of the entire area ensonified by pulsed sound levels ≥160 dB re 1 µPa rms from ZVSP surveys to be within areas ensonified by continuous sound levels ≥120 dB re 1 µPa rms, the estimated areas ensonified by the two different sound types, and associated number of activity days, were treated independently as an additional conservative measure (Table 6-6). After days were assigned to louder activity scenarios (e.g., MLC construction and anchor handling), the remaining days within each season were assigned to quieter, drilling-related scenarios.

The number of individuals that may occur at some point in time within the area ensonified to sounds above Level B thresholds during each season is likely to vary greatly by species, oceanographic conditions, and other factors. Individual marine mammals move into or out of exposed areas and new individuals move through subsequently (i.e., turnover). It is possible that this turnover of marine mammals within the ensonified area would be greater during the fall season than the summer season since many of the species present in the fall are migrating through the Chukchi Sea. However, wide ranging foraging patterns of some species may result in a similar amount of turnover within the ensonified area during the summer period as during migratory movements in the fall period. In either case, it is likely an overestimate to assume that the entire population of marine mammals within the ensonified area around each drill site or ice management location would turnover every day (i.e. a completely new set of individual marine mammals is present on a daily basis). Regardless, that is the assumption that has been made in calculating the estimates shown in Table 6-7, which result from multiplying the 'Total Area Potentially Ensonified' for each activity scenario shown in Table 6-6 by the density estimates for each season. For the reasons explained, the estimates of individual marine mammals potentially exposed to sounds above Level B thresholds shown in Table 6-7 are best interpreted as a very high estimate and one that is unlikely.

Table 6-6 Sound Propagation Modeling Results of Drilling Related Representative Activity Scenarios and Estimates of the Total Area Potentially Ensonified above Threshold Levels Summed on a Daily Basis at the Burger Prospect in the Chukchi Sea, Alaska, During the Planned 2015 Exploration Drilling Program

Activity Scenario Number	Activity Scenario Description	Threshold Level (dB re 1 µPa)	Single Day Area Potentially Ensonified (km^2)		Activity Days per Season		Total Area Potentially Ensonified (km^2)	
			Summer	Fall	Summer	Fall	Summer	Fall
1	Drilling at 1 site	120 dB	10.2	10.2	4	4	40.8	40.8
2	Drilling and DP Vessel at 1 site	120 dB	111.8	111.8	2	6	223.6	670.8
3	Drilling and DP Vessel (1 site) + Drilling and DP Vessel (2nd site)	120 dB	295.5	295.5	21	20	6,205.5	5,910.0
4	Mudline Cellar Construction at 2 different sites	120 dB	575.5	575.5	14	14	8,057.0	8,057.0
5	Anchor Handling at 1 site	120 dB	1,534.9	1,534.9	3	3	4,604.7	4,604.7
6	Drilling and DP Vessel at 1 site + Anchor Handling at 2nd site	120 dB	1,759.2	1,759.2	8	8	14,073.6	14,073.6
7	Mudline Cellar Construction at 2 different sites + Anchor Handling at 3rd site	120 dB	2,046.3	2,046.3	6	6	12,277.8	12,277.8
8	Two-vessel Ice Management	120 dB	937.4	937.4	20	10	18,748.0	9,374.0
9	Four-vessel Ice Management	120 dB	1,926.0	1,926.0	4	4	7,704.0	7,704.0
10	ZVSP at 2 different sites	160 dB	0.0	898.0	0	2	0.0	1,796.0

Table 6-7 The Total Number of Potential Exposures of Marine Mammals to Received Sound Levels ≥120 dB re 1 µPa rms or ≥160 dB re 1 µPa rms During the Planned Drilling Activities in the Chukchi Sea, Alaska, 2015. These Estimates Account for Marine Mammal Movements by Assuming a Complete Turnover of Individuals within the Ensonified Areas on a Daily Basis. All Fractional Values have been Rounded to the Nearest Whole Number. Totals Reflect the Sum of Fractional Values, Not the Sum of Rounded Values

	Total Number of Individuals Potentially Exposed to Sounds Continuous Sounds ≥120 dB re 1 µPa (rms) or Pulsed Sounds ≥160 dB e 1 µPa (rms)													
	Summer						Fall							
	Open Water		Ice Margin		Total		Open Water		Ice Margin		Total		Grand Total	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Odontocetes														
Monodontidae														
Beluga	55	111	472	964	527	1076	118	201	329	563	447	764	974	1840
Narwhal	0	0	0	5	0	5	0	0	0	3	0	3	0	9
Delphinidae														
Killer whale	2	9	5	20	7	29	4	15	3	11	6	26	14	55
Phocoenidae														
Harbor porpoise	50	66	108	143	158	209	80	167	56	117	135	284	294	492
Mysticetes														
Bowhead whale	43	155	93	335	137	489	2095	5009	2933	7013	5027	12022	5164	12511
Fin whale	2	9	5	20	7	29	4	15	3	11	6	26	14	55
Gray whale	575	609	1245	1318	1820	1928	448	941	313	659	761	1600	2581	3528
Humpback whale	2	9	5	20	7	29	4	15	3	11	6	26	14	55
Minke whale	7	14	15	30	22	43	11	23	8	16	19	39	41	82
Pinnipeds														
Bearded seal	242	461	699	1328	941	1789	404	768	377	717	781	1486	1722	3274
Ribbon seal	16	64	34	138	50	201	27	106	19	74	45	181	96	382
Ringed seal	8342	13815	24061	39847	32403	53662	9326	15444	8705	14416	18031	29861	50433	83523
Spotted seal	167	276	481	797	648	1073	186	307	173	287	359	594	1007	1667

Exposure Estimates Including Turnover and Modified Assumptions

Estimates of the numbers of marine mammals potentially exposed to continuous sounds ≥120 dB re 1 μPa rms or pulsed sounds ≥160 dB e 1 μPa rms in the section above, *Including Turnover of Individuals*, are overly conservative. Assumptions included upward scaling of source levels for all sound sources, assuming no avoidance of activities/sounds by individual marine mammals, and assuming 100% turnover of individuals in ensonified areas every 24 hours. The resulting exposure estimates are highly sensitive to any variation in these assumptions. Furthermore, many studies suggest that these assumptions are overly conservative, especially for non-migratory species/periods and for cetaceans in particular, which are known to avoid anthropogenic activities and associated sounds at varying distances depending on the context in which activities and sounds are encountered (Koski and Miller 2009; Moore 2000; Moore et al. 2000; Treacy et al. 2006). Although Shell recognizes these assumptions may be overly conservative, it is difficult to scale variables in a more precise fashion until recent evidence can be incorporated into newer methods.

The following sections present a range of exposure estimates for bowhead whales and ringed seals (other cetacean and pinniped species are mentioned when relevant to the topic and cited literature). Estimates were generated based on an evaluation of the best available science and a reconsideration of the assumptions surrounding avoidance behavior and the frequency of turnover. In addition to demonstrating the sensitivity of exposure estimates to variable assumptions, the wide range of estimates is more informative for assessing negligible impact compared to a single estimated value with a high degree of uncertainty.

Bowhead Whales

It is difficult to determine an appropriate, precise average turnover time for a population of animals in a particular area of the Chukchi Sea. Reasons for this include differences in residency time for migratory and non-migratory species, changes in distribution of food and other factors such as behavior that influence animal movement, variation among individuals of the same species, etc. Complete turnover of individual bowhead whales in the project area each 24 hour period may occur during fall migration when bowheads are traveling through the area. Even during this fall period, bowheads often move in pulses with one to several days between major pulses of whales (Miller et al. 2002). Gaps between groups of whales can probably be accounted for partially by bowhead whales stopping to feed opportunistically when food is encountered. The extent of feeding by bowhead whales during fall migration across the Beaufort and Chukchi Seas varies greatly from year to year based on the location and abundance of prey (Shelden and Mocklin 2013). For example, if a turnover rate of 48 hours to account for intermittent periods of migrating and feeding individuals is assumed, then the bowhead whale exposure estimate would be reduced accordingly by 50%. Due to changes in the turnover rate across time, a conservative turnover rate of 24 hours has been selected to estimate exposures for bowhead whales.

During the summer, relatively few bowhead or beluga whales are present in the Chukchi Sea and in most cases, given that the operations area is not known to be a critical feeding area (Citta et al. 2014; Allen and Angliss 2014), whales would be likely to simply avoid the area of operations (Schick and Urban 2000; Richardson et al. 1995a). Similarly, during migration many whales would likely travel around the area (i.e., avoid it) as it is not known to be important habitat for either bowheads or belugas during any portion of the year (Citta et al. 2014; Allen and Angliss 2014). There is a large body of evidence indicating that bowhead whales avoid anthropogenic activities and associated underwater sounds depending on the context in which these activities are encountered (LGL et al. 2014; Koski and Miller 2009; Moore 2000; Moore et al. 2000; Treacy et al. 2006). Increasing evidence suggests that proximity to an activity or sound source, coupled with an individual's behavioral state (e.g., feeding vs traveling) among other contextual variables, as opposed to received sound level alone, strongly influences the degree to which an individual whale demonstrates aversion or other behaviors (reviewed in Richardson et al. 1995b; Gordon et al. 2004;

Koski and Miller 2009; Ljungblad et al. 1988; Miller et al. 2005; Moore 2000; Moore et al. 2000; Treacy et al. 2006).

Several historical studies provide valuable information on the distribution and behavior of bowhead whales relative to drilling activities in the Alaskan Arctic offshore. One is a 1986 study by Shell at Hammerhead and Corona prospects (Davis 1987) and another is an analysis by Schick and Urban (2000) of 1993 aerial survey data collected by Coastal Offshore and Pacific Corporation. Both studies suggest that few whales approached within ~18 km of an offshore drilling operation in the Beaufort Sea. Davis (1987) reported that the surfacing and respiration variables that are often used as indicators of behavioral disturbance seemed normal when whales were >18.5 km from the active drill site and as they circumnavigated the drilling operation. The Schick and Urban (2000) study found whales as close as 18.5–20.3 km in all directions around the active operation, suggesting that whales that had diverted returned to their normal migration routes shortly after passing the operation.

If bowhead whales avoid drilling and related support activities at distances of approximately 20 km in 2015, as was noted consistently by Davis (1987) and Schick and Urban (2000), this would preclude exposure of the vast majority of individuals to continuous sounds ≥120 dB re 1 μPa rms or pulsed sounds ≥160 dB e 1 μPa rms. The largest ensonified areas during Shell's 2012 exploration drilling program were produced by mudline cellar construction, ice management, and anchor handling (JASCO Applied Sciences and Greeneridge Sciences 2014). Only anchor handling is expected to result in the lateral propagation of continuous sound levels ≥120 dB re 1 μPa rms to distances of 20 km or greater from the source, as is evident in the depiction of activity scenario 7 in Figure 6-3.

By assuming half of the individual bowhead whales would avoid areas with sounds above Level B thresholds, the exposure estimate would be reduced accordingly by 50% even if 100% turnover of migrating whales was still assumed to take place every 24 hours. These behaviors have also been recognized by NMFS and incorporated into previous authorizations. For example, NMFS stated in the Notice of Issuance for Shell's 2012 drilling IHA in the Beaufort Sea (77 Fed. Reg. 27284, 27288 [May 9, 2012]),

"Bowheads may engage in avoidance behavior preventing their exposure to these levels of sound, and, even if exposed, may not exhibit a behavioral reaction."

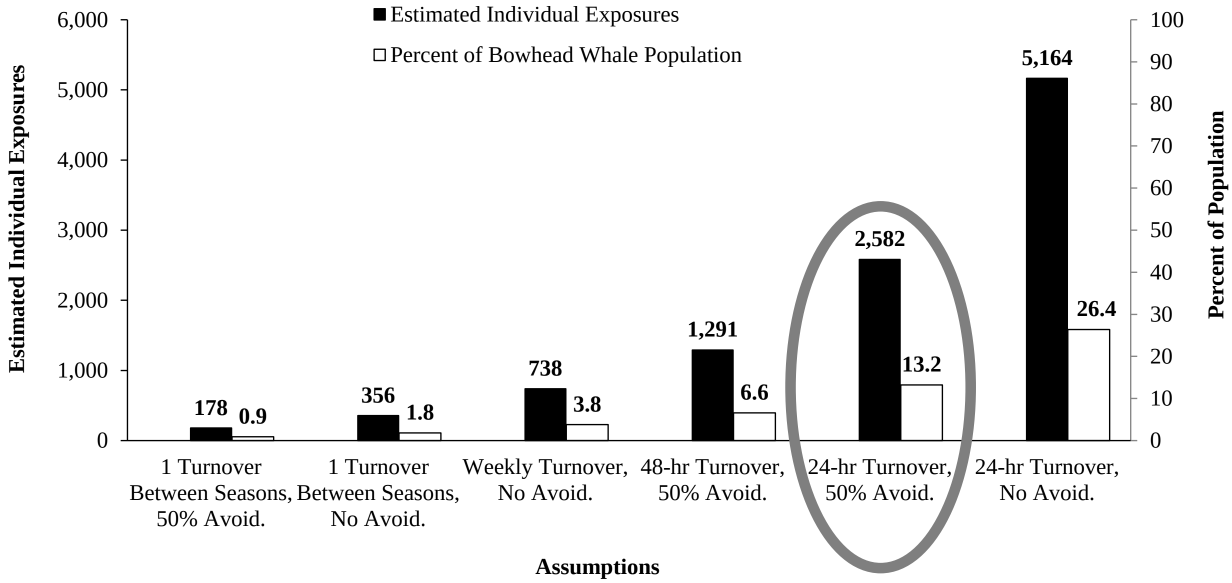
Also, NMFS states in the same notice,

"Although it is possible that marine mammals could react to any sound levels detectable above the ambient noise level within the animals' respective frequency response range, this does not mean that such a reaction would be considered a take. According to experts on marine mammal behavior, whether a particular stressor could potentially disrupt the migration, breathing, nursing, breeding, feeding, or sheltering, etc., of a marine mammal, i.e., whether it would result in a take, is complex and context specific, and it depends on several variables in addition to the received level of the sound by the animals." 77 Fed. Reg. at 27290.

Figure 6-5 presents several examples of bowhead whale exposure estimates that were generated based on our re-evaluation of the best available science and a reconsideration of the assumptions surrounding bowhead whale avoidance and the frequency of turnover. Also shown for each exposure estimate is the corresponding percentage of the projected 2015 bowhead whale population of 19,534. This value is based on the Givens et al. 2013 bowhead whale abundance estimate of 16,892 individuals in 2011 with an annual growth rate of 3.7%.

Taking into consideration what is known from studies documenting temporary diversion around drilling activities as recognized by NMFS, and conservative assumptions with regards to turnover rates, Shell considers the conservative estimate associated with a 24 hour turnover and 50% avoidance to be the most reasonable estimate of individual exposures (columns enclosed by oval in Figure 6-5; n=2,582 individuals).

Figure 6-5 Exposure Estimates for Bowhead Whales and Corresponding Percent of the Projected 2015 Population for Different Avoidance and Turnover Rate Assumptions



Ringed Seals

Data for some seal species suggest they may not avoid offshore exploration activities and associated sounds to the degree demonstrated by many cetaceans. Recent evidence suggests little change in the distribution of seals around offshore drilling operations. Moulton et al. (2005) reported that ringed seal densities in spring did not appear to be affected by proximity to construction, drilling, and oil production activities at a man-made island in the Beaufort Sea. There was no apparent difference in the detection distances and distributions of seals around Shell's two drilling units in 2012 when comparing periods of active drilling to non-drilling periods (LGL and JASCO 2014).

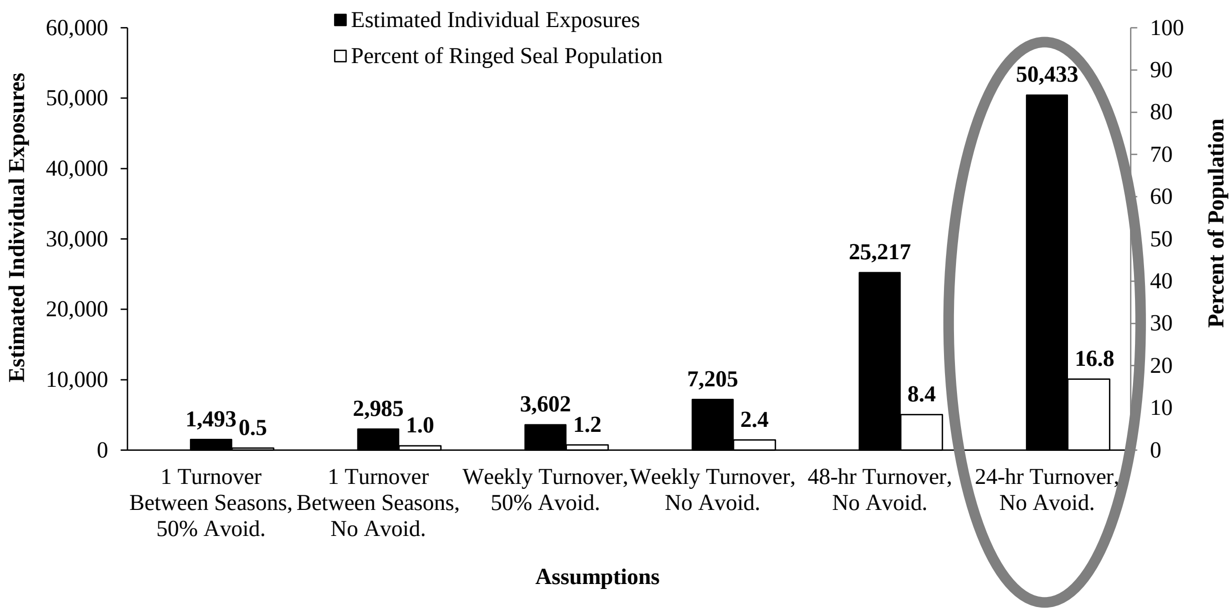
Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). Some evidence, however, suggests that avoidance of active airguns by phocid seals in the Arctic may occur at slightly greater distances. Reiser et al. (2009b) reported a tendency for localized avoidance of areas immediately around the seismic source vessel along with coincident increased sighting rates at support vessels operating 1–2 km away.

The turnover of individual seals in operational areas may not be as frequent as it is for cetaceans, at least for much of the operational period. Recent evidence from monitoring conducted in support of Shell's 2012 exploration drilling program is informative for assessing turnover rates of seals around an active drilling unit. PSOs conducted detailed visual monitoring of seals in the Beaufort Sea from the *Kulluk* while it was drilling a pilot hole and excavating a mudline cellar in 2012. PSOs were able to identify individual ringed and bearded seals through unique markings on their pelage that were then documented and catalogued using high definition photographs. In total, 15 distinct, individual seals were identified; 12 ringed and 3 bearded (Patterson et al. 2014). Observations of these seals indicated numerous individuals were spending extended periods in the vicinity of the drilling unit. The time periods from when each of these seals was first identified as a unique individual to the last sighting of each respective individual ranged from 6 to 24 days (Patterson et al. 2014). These results suggest that assuming 100% turnover of all individual seals around an offshore drilling operation on a daily basis is unreasonable, and a period closer to a week may be more appropriate and yet still conservative for other individuals that remained in the area for longer periods.

Figure 6-6 shows exposure estimates for ringed seals based on similar assumptions of avoidance and turnover rate as described for bowhead whales in this section. The value chosen for the ringed seal population was 300,000 individuals. Kelly et al. (2010) stated that this number is likely an underestimate for the Chukchi-Beaufort Seas population because surveys in the Beaufort Sea were limited to areas within 40 km of the shore. In its final decision to list several subspecies of ringed seals as threatened under the U.S. Endangered Species Act, NMFS (2012b) concluded ringed seals in the Arctic likely number in the millions. Nonetheless, 300,000 was selected as a more localized estimate despite it being an underestimate.

Thus, considering what is known from visual observations of seals in the Alaskan Arctic during drilling activities, Shell considers the conservative exposure estimate associated with 24-hour turnover and zero avoidance to be an overestimate of individual exposures. Although evidence exists to indicate a turnover period of a week or more for individual seals near a drilling operation in the Alaskan Arctic (Patterson et al. 2014), more data and analysis are necessary to determine a precise and reliable turnover rate for seal populations in the activity area. Similarly, studies have also investigated potential avoidance of anthropogenic activities and associated underwater sounds by ice seals. However, these studies have not yielded a clear understanding of how ice seals react to underwater sound (Blackwell et al. 2004; Moulton et al. 2005; Harris et al. 2001; Bain and Williams 2006; Reiser et al. 2009b). As a result, the exposure estimate for ringed seals that assumes a daily turnover rate and zero avoidance has been selected (column enclosed by oval in Figure 6-6; n=50,433 individuals).

Figure 6-6 Exposure Estimates for Ringed Seals and Corresponding Percent of the Estimated Population for Different Avoidance and Turnover Rate Assumptions



Summary of Final Exposure Estimates and Percentages of Populations

Table 6-8 presents Shell's final exposure estimates for the proposed 2015 exploration drilling program in the Chukchi Sea. The table also summarizes abundance estimates for each species and the corresponding percent of each population that may be exposed to continuous sounds ≥120 dB re 1 µPa rms or pulsed sounds ≥160 dB e 1 µPa rms. With the exception of the exposure estimate for bowhead whales described above, estimates for all other species assumed 100% daily turnover and no avoidance of activities or ensonified areas. Although considerable evidence suggests these assumptions will result in an overestimation of exposures, more time is needed to refine methods that accurately capture turnover rates and avoidance correction factors for each species.

It is important to note that very few reliable population estimates exist for Arctic marine mammal species. In most cases, the best available abundance estimate for a population incorporates only a portion of the known range and distribution for the species. As a result, many of the existing population estimates are likely biased low (e.g., Kelly et al. 2010; Allen and Angliss 2014), causing an overestimate of the percentage of individuals within that population that could be exposed to current Level B thresholds. Additionally, there are multiple, wide-ranging abundance estimates available for several species, but many are outdated or associated with low degrees of confidence (e.g., DeMaster 1998; Allen and Angliss 2014), which further adds to the difficulty of selecting a truly representative population estimate for a given species. All of these factors should be kept in mind when interpreting the final exposure estimates and corresponding percentages of populations presented in Table 6-8.

Table 6-8 The Total Number of Potential Exposures of Marine Mammals to Sound Levels ≥120 dB re 1 µPa rms or ≥160 dB re 1 µPa rms During the Planned Drilling Activities in the Chukchi Sea, Alaska, 2015. Estimates are also shown as a Percent of Each Population

Species	Abundance Estimate*	Number of Individuals Potentially Exposed to Continuous Sounds ≥120 dB re 1 µPa (rms) or Pulsed Sounds ≥160 dB e 1 µPa (rms)**	Percent of Estimated Population
Odontocetes			
Monodontidae			
Beluga	42,968[1]	974	2.3
Narwhal	NA[2]	1	0.0
Delphinidae			
Killer whale	2,084[3]	14	0.7
Phocoenidae			
Harbor porpoise	48,215[4]	294	0.6
Mysticetes			
Bowhead whale	19,534[5]	2,582	13.2
Fin whale	1,652[6]	14	0.8
Gray whale	19,126[7]	2,581	13.5
Humpback whale	20,800[8]	14	0.1
Minke whale	810[9]	41	5.1
Pinnipeds			
Bearded seal	155,000[10]	1,722	1.1
Ribbon seal	49,000[11]	96	0.2
Ringed seal	300,000[12]	50,433	16.8
Spotted seal	141,479[13]	1,007	0.7

*With the exception of bowhead and gray whale, reliable population estimates do not exist and these percentages should be interpreted with care. Additionally, the best available abundance estimates often include only a portion of the known distribution and range for a given population, which results in overestimation of the percent of individuals exposed within those populations.

**Assumptions for each species included 100% daily turnover and no avoidance of ensonified areas with the exception of bowhead whale, for which 100% daily turnover and 50% avoidance of ensonified areas were assumed.

[1] Allen and Angliss 2014, sum of minimum population estimates for Eastern Chukchi and Beaufort Sea Stocks

[2] Allen and Angliss, 2014; Narwhals in Alaska are extremely rare, no reliable abundance estimate for this species

[3] Allen and Angliss 2014, minimum population estimate for Eastern North Pacific Alaska Resident Stock

[4] Allen and Angliss 2014, considered conservative estimate for Bering Sea Stock

[5] Givens et al. 2013, projected 2015 population using 2011 census of Bering-Chukchi-Beaufort Stock of 16,892 with annual growth rate of 3.7%

[6] Allen and Angliss 2014, conservative estimate of Northeast Pacific Stock from Zerbini et al. 2006 surveys of Western Alaska conducted during 2001-2003

[7] Laake et al. 2009, estimate for entire North Pacific population

[8] Allen and Angliss 2014, estimate for entire North Pacific population

[9] Allen and Angliss 2014, conservative estimate of Alaska Stock from Moore et al. 2002 surveys in the central-eastern and southeastern Bering Sea

[10] Allen and Angliss 2014, estimate from Cameron et al. 2010 sum of bearded seals in Bering and Chukchi Seas

[11] Allen and Angliss 2014, based on recent provisional estimate by Boveng et al. 2008

[12] Allen and Angliss 2014, conservative estimate from Kelly et al. 2010 for Chukchi and Beaufort Seas

[13] Allen and Angliss 2014, conservative estimate from Ver Hoef et al. *in review* for areas surveyed in eastern and central Bering Sea in 2007

Several precautionary methods were applied when calculating exposure estimates. These conservative methods and related considerations include:

- Application of a 1.3 dB re 1 µPa rms safety factor to the source level of each continuous sound source prior to sound propagation modeling of areas exposed to Level B thresholds;
- Binning of similar activity scenarios into a representative scenario, each of which reflected the largest exposed area for a related group of activities;
- Modeling numerous iterations of each activity scenario at different drill site locations to identify the spatial arrangement with the largest exposed area for each;
- Assuming 100 percent daily turnover of populations, which likely overestimates the number of different individuals that would be exposed, especially during non-migratory periods;
- Expected marine mammal densities assume no avoidance of areas exposed to Level B thresholds (with the exception of bowhead whale, for which 50% of individuals were assumed to demonstrate avoidance behavior); and;
- Density estimates for some cetaceans include nearshore areas where more individuals would be expected to occur than in the offshore Burger Prospect area (e.g., gray whales).

Additionally, post-season estimates of the number of marine mammals exposed to Level B thresholds per Shell 90-Day Reports consistently support the methods used in Shell's IHA applications as precautionary. Most recently, exposure estimates reported by Reider et al. (2013) from Shell's 2013 exploration activities in the Chukchi Sea were considerably lower than those requested in Shell's 2012 IHA application. The following summary of the numbers of cetaceans and pinnipeds that may be exposed to sounds above Level B thresholds is best interpreted as conservatively high, particularly the larger value for each species that assumes a new population of individuals each day. New methods are currently being developed that will incorporate the best available science to support more realistic estimation of marine mammal exposures.

Cetaceans

Shell estimates 2,582 bowhead whales may be exposed to sounds at or above the Level B thresholds during the proposed 2015 exploration drilling program in the Chukchi Sea (Table 6-8). This estimate is approximately 13 percent of the expected 2015 BCB population of ~19,534 assuming 3.7 percent annual population growth from the 2011 estimate of 16,892 animals (Givens et al. 2013; Table 6-8). This most recent estimate of the BCB bowhead population is consistent with previous abundance estimates and growth rates reported during the last decade (Zeh and Punt 2005; Koski et al. 2010). Fewer beluga and gray whales may be exposed to sounds from the exploration drilling program and would represent smaller percentages of their respective populations compared to those calculated for bowhead whales. The small numbers of other whales that may occur in the Chukchi Sea are unlikely to be present around the planned exploration drilling activities but chance encounters may occur. The few individuals would represent only a very small proportion of their respective populations (Table 6-8).

Pinnipeds

Ringed seal is by far the most abundant species expected to be encountered during the planned exploration drilling activities. The estimated number of individual ringed seals potentially exposed to sounds above threshold levels during the proposed exploration drilling program is 50,433, which represents approximately 17 percent of the estimated Chukchi-Beaufort Seas population (Table 6-8). It should be noted that NMFS (2012b) believes there to be likely millions of ringed seals in the Arctic; however, the Kelly et al. (2010) population estimate of 300,000 ringed seals was chosen due to its localized nature with respect to proposed operations. Fewer individuals of other pinniped species are estimated to be exposed to sounds at the specified received levels, also representing small proportions of their populations (Table 6-8).

7. ANTICIPATED IMPACT OF THE ACTIVITY

The reasonably expected or reasonably likely impacts of the specified activities on marine mammal populations will be related primarily to acoustic effects. Petroleum exploration and associated activities in marine waters introduce sound into the environment. The acoustic sense of marine mammals probably constitutes their most important distance receptor system, and underwater sounds could (at least in theory) have several types of effects on marine mammals. Potential acoustic effects discussed relate to sound produced by the anticipated exploration drilling activity, vessels and aircraft.

This section first identifies potential types of sound related impacts and then addresses the impacts that could result from various elements of the proposed activity. Hearing impacts and other potential physical effects, strandings, and mortality are discussed at the conclusion of the section.

Sound Characteristics and Effects Overview

The effects of sound on marine mammals are highly variable, and can be categorized as follows (based on Richardson et al. 1995a):

1. The sound may be too weak to be heard at the location of the animal, i.e. lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both.
2. The sound may be audible but not strong enough to elicit any overt behavioral response. This has been demonstrated upon exposure of bowhead whales to low levels of seismic, drilling, dredge, or icebreaker sounds (Richardson et al. 1986; 1990; 1995a,b,).
3. The sound may elicit reactions of variable conspicuousness and variable relevance to the wellbeing of the animal. These can range from subtle effects on respiration or other behaviors (detectable only by statistical analysis) to active avoidance reactions.
4. Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist. The latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat.
5. Any man made sound that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as ice or surf noise.
6. Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity. Effects of sounds on hearing thresholds of some marine mammals species have been studied (e.g., Finneran et al. 2005; Mooney et al. 2009; Kastak et al. 2005). Received sound levels must far exceed the animal's hearing threshold for any Temporary Threshold Shift (TTS) to occur. The TTS threshold depends on duration of exposure; the sound level necessary to cause TTS is higher for short sound exposures than for long sound exposures. Received levels must be even higher to risk permanent hearing impairment (probably at least 10 dB above the TTS threshold).

Drilling Sounds

Exploration drilling will be conducted from the drilling units *Discoverer* and *Polar Pioneer*. Underwater sound propagation during the activities results from the use of generators, drilling machinery, and the drilling units themselves. Sound levels during vessel-based operations may fluctuate depending on the specific type of activity at a given time and aspect from the vessel. Underwater sound levels may also depend on the specific equipment in operation. Lower sound levels have been reported during well logging than during drilling operations (Greene 1987b), and underwater sound appeared to be lower at the bow and stern aspects than at the beam (Greene 1987a).

Most drilling sounds generated from vessel-based operations occur at relatively low frequencies below 600 Hz although tones up to 1,850 Hz were recorded by Greene (1987a) during drilling operations in the Beaufort Sea. At a range of 0.17 km, the 20-1000 Hz band level was 122-125 dB re 1μPa rms for the drillship *Explorer I*. Underwater sound levels were slightly higher (134 dB re 1μPa rms) during drilling activity from the *Explorer II* at a range of 0.20 km; although tones were only recorded below 600 Hz. Underwater sound measurements from the *Kulluk* in 1986 at 0.98 km were higher (143 dB re 1μPa rms) than from the other two vessels. Measurements of the *Discoverer* on the Burger prospect in 2012, without any support vessels operating nearby, showed received sound levels of 120 dB re 1 μPa rms at 1.5 km. The *Polar Pioneer*, a semi-submersible drilling unit, is expected to introduce less sound into the water than the *Discoverer* during drilling and related activities.

Airgun Sounds

Two sound sources have been proposed by Shell for the ZVSP surveys in 2015. The first is a small airgun array that consists of three 150 in^3 (2,458 cm^3) airguns for a total volume of 450 in^3 (7,374 cm^3). The second ZVSP sound source consists of two 250 in^3 (4097 cm^3) airguns with a total volume of 500 in^3 (8,194 cm^3). Typically, a single ZVSP survey will be performed when the well has reached PTD or final depth although, in some instances, a prior ZVSP will have been performed at a shallower depth. A typical survey, would last 10–14 hours, depending on the depth of the well and the number of anchoring points, and include firings of up to the full array, plus additional firing of the smallest airgun in the array to be used as a "mitigation airgun" while the geophones are relocated within the wellbore.

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle. A typical high-energy airgun arrays emit most energy at 10–120 Hz. However, the pulses contain energy up to 500–1000 Hz and some energy at higher frequencies (Goold and Fish 1998; Potter et al. 2007).

Aircraft Noise

Helicopters may be used for personnel and equipment transport to and from the drilling units and support vessels. Under calm conditions, rotor and engine sounds are coupled into the water within a 26°(degree) cone beneath the aircraft. Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 26º area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in the shallow water.

Dominant tones in noise spectra from helicopters are generally below 500 Hz (Greene and Moore 1995). Harmonics of the main rotor and tail rotor usually dominate the sound from helicopters; however, many additional tones associated with the engines and other rotating parts are sometimes present.

Because of doppler shift effects, the frequencies of tones received at a stationary site diminish when an aircraft passes overhead. The apparent frequency is increased while the aircraft approaches and is reduced while it moves away.

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drilling units will generally maintain straight-line routes at altitudes of 1,500 ft. (457 m) above sea level, thereby limiting the received levels at and below the surface.

Vessel Noise

In addition to the drilling units, various types of vessels will be used in support of the operations including ice management vessels, anchor handlers, OSVs, and OSR vessels. Sounds from boats and vessels have been reported extensively (Greene and Moore 1995; Blackwell and Greene 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort Seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007. For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB re 1 μPa rms at distances ranging from ~1.5 to 2.3 mi (~2.4 to 3.7 km) from various types of barges. MacDonnell et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 dB re 1 μPa rms at ~13 mi (~21 km) from the source, although the sound level was only 150 dB re 1 μPa rms at 85 ft. (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally at relatively low frequencies. During 2012, underwater sound from ten (10) vessels in transit, and in two instances towing or providing a tow-assist, were recorded by JASCO in the Chukchi Sea as a function of the Sound Source Characterization (SSC) study required in the Shell 2012 Chukchi Sea drilling IHA. SSC transit and tow results from 2012 include ice management vessels, an anchor handler, OSR vessels, the OST, support tugs, and OSVs. The recorded sound pressure levels to 120 dB re 1 μPa rms for vessels in transit primarily range from ~ 0.8 mi – 4.3 mi (1.3 - 6.9 km), whereas the measured 120 dB re 1 μPa rms for the drilling unit *Kulluk* under tow by the *Aiviq* in the Chukchi Sea was ~ 11.8 mi (19 km) on its way to the Beaufort Sea (O'Neill and McCrodan 2012a,b). Measurements of vessel sounds from Shell's 2012 exploration drilling program in the Chukchi Sea are presented in detail in the 2012 Comprehensive Monitoring Report (LGL et al. 2014).

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake. Icebreakers contribute greater sound levels during ice-breaking activities than ships of similar size during normal operation in open water (Richardson et al. 1995a). This higher sound production results from the greater amount of power and propeller cavitation required when operating in thick ice.

Summary of Potential Effects of Exposure to Underwater Sounds from Drilling and Associated Activities

The potential effects of underwater sounds from the proposed exploration drilling activities and associated activities might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995a). It is unlikely that there would be any cases of temporary or especially permanent hearing impairment, or non-auditory physical effects.

Tolerance

Numerous studies have shown that underwater sounds from industry activities are often readily detectable in the water at distances of many kilometers. As described below, numerous studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response to industry activities of various types (Moulton et al. 2005, Harris et al. 2001, LGL et al. 2014). This is often true even in cases when the sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to underwater sound such as airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions (Stone and Tasker 2006, Hartin et al. 2013) . In general, pinnipeds and small odontocetes seem to be more tolerant of exposure to some types of underwater sound than are baleen whales. Based upon the above information regarding marine mammal tolerance to underwater sounds, Shell anticipates that some marine mammals exposed to low levels of underwater sounds from exploratory drilling and associated activity will show no response.

Masking

There are no definitive studies to identify the size of the potential area of masking around a drilling unit. As noted above, drilling sounds are relatively low-frequency and would not result in masking impacts for marine mammals with higher-frequency hearing sensitivities such as toothed whales. Masking of the ability of individuals to hear other animals or to make their calls heard by other individuals could occur in proximity to operations, particularly for species with lower-frequency hearing sensitivities such as baleen whales. Larger numbers of animals could experience masking in a year when oceanographic conditions created feeding opportunities in and around the project area that attracted greater numbers of individuals into areas closer to operations.

Masking effects of drilling sounds are expected to be minimal given the relatively small acoustic footprint from drilling, and the fact that ringed seals (the most abundant species in the area) are not typically vocal during this period. Based upon the above information regarding the masking effects of underwater sounds on marine mammal calls and other natural sounds, Shell anticipates any such impacts related to underwater sounds from drilling and associated activities to be minimal.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Based on NMFS (2001), we assume that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially material manner, do not constitute harassment or “taking”. By potentially material, we mean “in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations”.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be material to the individual, let alone the stock or the species as a whole. In predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. This practice; however, likely overestimates the numbers of marine mammals that are affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically important degree by industrial sounds are based on behavioral observations during studies of several species. Detailed studies have been done on humpback, gray, and bowhead whales, and on ringed seals.

Less detailed data are available for some other species of baleen whales, sperm whales, small toothed whales, and sea otters.

(a) Mysticetes

Richardson et al. (1995b) reported changes in surfacing and respiration behavior, and the occurrence of turns during surfacing in bowhead whales exposed to playback of underwater sound from drilling activities. These subtle behavioral effects were temporary and localized, and occurred at distances up to 1.2-2.5 mi (2-4 km). Safety radii for the proposed drilling activities are expected to be small and are not expected to result in material disturbance to baleen whales.

Some bowheads appeared to divert from their migratory path after exposure to projected icebreaker sounds. Other bowheads, however, tolerated projected icebreaker sound at levels ≥20 dB re 1 μPa rms above ambient sound levels. The source level of the projected sound however, was much less than that of an actual icebreaker, and reaction distances to actual ice breaking may be much greater than those reported here for projected sounds.

Brewer et al. (1993) and Hall et al. (1994) reported numerous sightings of marine mammals including bowhead whales in the vicinity of offshore drilling operations in the Beaufort Sea. One bowhead whale sighting was reported within ~400 m of a drilling vessel although most other bowhead sightings were at much greater distances. Few bowheads were recorded near industrial activities by aerial observers. After controlling for spatial autocorrelation in aerial survey data from Hall et al. (1994) using a Mantel test, Schick and Urban (2000) found that the variable describing straight line distance between the rig and bowhead whale sightings was not significant, but that a variable describing threshold distances between sightings and the rig was significant. Thus, although the aerial survey results suggested substantial avoidance of the operations by bowhead whales, observations by vessel-based observers indicate that at least some bowheads may have been closer to industrial activities than was suggested by results of aerial observations.

Richardson et al. (2008) reported a slight change in the distribution of bowhead whale calls in response to operational sounds on BP’s Northstar Island. The southern edge of the call distribution ranged from 0.47 to 1.46 mi (0.76 to 2.35 km) farther offshore, apparently in response to industrial sound levels. This result however, was only achieved after intensive statistical analyses, and it is not clear that this represented a biologically material effect.

Patenaude et al. (2002) reported fewer behavioral responses to aircraft overflights by bowhead compared to beluga whales. Behaviors classified as reactions consisted of short surfacing, immediate dives or turns, changes in behavior state, vigorous swimming, and breaching. Most bowhead reaction resulted from exposure to helicopter activity and little response to fixed-wing aircraft was observed. Most reactions occurred when the helicopter was at altitudes ≤492 ft. (≤150 m) and lateral distances ≤820 ft. (≤250 m). Restriction on aircraft altitude will be part of the mitigation measures during the proposed exploration drilling activities and likely to have little or no disturbance effects on baleen whales. Any disturbance that did occur would likely be temporary and localized.

Southall et al. (2007 Appendix C) reviewed a number of papers describing the responses of marine mammals to non-pulsed sound. In general, little or no response was observed in animals exposed at received levels from 90-120 dB re 1 μPa rms. Probability of avoidance and other behavioral effects increased when received levels were 120-160 dB re 1 μPa rms. Some of the relevant reviews of Southall et al. (2007) are summarized below.

Baker et al. (1982) reported some avoidance by humpback whales to vessel noise when received levels were 110-120 dB re 1 μPa rms, and clear avoidance at 120-140 dB re 1 μPa rms (sound measurements were not provided by Baker but were based on measurements of identical vessels by Miles and Malme 1983).

Malme et al. (1983, 1984) used playback of sound from helicopter overflight and drilling rigs and platforms to study behavioral effects on migrating gray whales. Received levels exceeding 120 dB re 1 μPa rms induced avoidance reactions. Malme et al. (1984) calculated 10, 50, and 90 percent probabilities of gray whale avoidance reactions at received levels of 110, 120, and 130 dB re 1 μPa rms, respectively.

Malme et al. (1986) observed the behavior of feeding gray whales during four experimental playbacks of drilling sounds (50 to 315 Hz; 21-minutes (min) overall duration and 10 percent duty cycle; source levels 156 to 162 dB re 1 μPa-m). In two cases for received levels of 100 to 110 dB re 1 μPa, no behavioral reaction was observed. Avoidance behavior was observed in two cases where received levels were 110 to 120 dB re 1 μPa rms.

Richardson et al. (1990) performed 12 playback experiments in which bowhead whales in the Alaskan Arctic were exposed to drilling sounds. Whales generally did not respond to exposures in the 100 to 130 dB re 1 μPa rms range, although there was some indication of behavioral changes in several instances.

McCauley et al. (1996) reported several cases of humpback whales responding to vessels in Hervey Bay, Australia. Results indicated clear avoidance at received levels between 118 to 124 dB re 1 μPa rms in three cases for which response and received levels were observed / measured.

Palka & Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of Minke whales. Changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847 to 2,352 ft. (563 to 717 m) at received levels (RLs) of 110 to 120 dB re 1 μPa rms.

Frankel & Clark (1998) conducted playback experiments with wintering humpback whales using a single speaker producing a low-frequency “M-sequence” (sine wave with multiple-phase reversals) signals in the 60 to 90 Hz band with output of 172 dB re 1 μPa rms. For 11 playbacks, exposures were between 120 and 130 dB re 1 μPa and included sufficient information regarding individual responses. During eight of the trials, there were no measurable differences in tracks or bearings relative to control conditions, whereas on three occasions, whales either moved slightly away from (n = 1) or towards (n = 2) the playback speaker during exposure. The presence of the source vessel itself had a greater effect than did the M-sequence playback.

Finally, Nowacek et al. (2004) used controlled exposures to demonstrate behavioral reactions of northern right whales to various nonpulse sounds. Playback stimuli included ship noise, social sounds of conspecifics, and a complex, 18-min “alert” sound consisting of repetitions of three different artificial signals. Ten whales were tagged with calibrated instruments that measured received sound characteristics and concurrent animal movements in three dimensions. Five out of six exposed whales reacted strongly to alert signals at measured received levels between 130 and 150 dB re 1 μPa rms (i.e., ceased foraging and swam rapidly to the surface). Two of these individuals were not exposed to ship noise and the other four were exposed to both stimuli. These whales reacted mildly to conspecific signals. Seven whales, including the four exposed to the alert stimulus, had no measurable response to either ship sounds or actual vessel noise.

Based upon the above information regarding baleen whale disturbance reactions, Shell anticipates that some baleen whales may exhibit minor, short-term disturbance responses to underwater sounds from drilling and associated support activities. Any potential impacts on baleen whale behavior would be localized within the activity area and would not result in population-level effects.

(b) Odontocetes

Most toothed whales have the greatest hearing sensitivity at frequencies much higher than that of baleen whales and may be less responsive to low-frequency sound commonly associated with industry activities. Richardson et al. (1995a) reported that beluga whales did not show any apparent reaction to playback of underwater drilling sounds at distances greater than 656–1,312 ft. (200-400 m). Reactions included slowing down, milling, or reversal of course after which the whales continued past the projector, sometimes within 164-328 ft. (50-100 m). The authors concluded (based on a small sample size) that playback of drilling sound had no biologically material effects on migration routes of beluga whales migrating through pack ice and along the seaward side of the nearshore lead east of Pt. Barrow in spring.

At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson et al. 1995b). Received levels from the icebreaker playback were estimated at 78-84 dB re 1 μPa rms in the 1/3-octave band centered at 5,000 Hz, or 8-14 dB re 1 μPa rms above ambient. If beluga whales reacted to an actual icebreaker at received levels of 80 dB, reactions would be expected to occur at distances on the order of 6 mi (10 km). Finley et al. (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 22 to 31 mi (35 to 50 km). In addition to avoidance, changes in dive behavior and pod integrity were also noted. Beluga whales have also been report to avoid active seismic vessels at distances of 6-12 mi (10-19 km) (Miller et al. 2005). It is likely that at least some beluga whales may avoid the vicinity of the proposed activities thus reducing the potential for exposure to high levels of underwater sound.

Patenaude et al. (2002) reported that beluga whales appeared to be more responsive to aircraft overflights than bowhead whales. Changes were observed in diving and respiration behavior, and some whales veered away when a helicopter passed at ≤820 ft. (≤250 m) lateral distance at altitudes up to 492 ft. (150 m). However, some belugas showed no reaction to the helicopter. Belugas appeared to show less response to fixed-wing aircraft than to helicopter overflights.

In reviewing responses of cetaceans with best hearing in mid-frequency ranges, which includes toothed whales, Southall et al. (2007) reported that combined field and laboratory data for mid-frequency cetaceans exposed to nonpulse sounds did not lead to a clear conclusion about received levels coincident with various behavioral responses. In some settings, individuals in the field showed profound behavioral responses to exposures from 90 to 120 dB re 1 μPa rms, while others failed to exhibit such responses for exposure to received levels from 120 to 150 dB re 1 μPa rms. Contextual variables other than exposure received level, and probable species differences, are the likely reasons for this variability. Context, including the fact that captive subjects were often directly reinforced with food for tolerating noise exposure, may also explain why there was great disparity in results from field and laboratory conditions—exposures in captive settings generally exceeded 170 dB re 1 μPa rms before inducing behavioral responses. Below we summarize some of the relevant material reviewed by Southall et al. (2007).

LGL and Greeneridge (1986) and Finley et al. (1990) documented belugas and narwhals congregated near ice edges reacting to the approach and passage of icebreaking ships. Beluga whales responded to oncoming vessels by (1) fleeing at speeds of up to 20 kilometers per hour (km/hr.) from distances of 12 to 50 mi (19 to 80 km), (2) abandoning normal pod structure, and (3) modifying vocal behavior and/or emitting alarm calls. Narwhals, in contrast, generally demonstrated a “freeze” response, lying motionless or swimming slowly away (as far as 23 mi/37 km down the ice edge), huddling in groups, and ceasing sound production. There was some evidence of habituation and reduced avoidance 2 to 3 days after onset.

The 1982 season observations by LGL & Greeneridge (1986) involved a single passage of an icebreaker with both ice-based and aerial measurements on 28 June 1982. Four groups of narwhals (n = 9 to 10, 7, 7, and 6) responded when the ship was 4.0 mi (6.4 km away) with received levels of ~100 dB re 1 μPa rms in the 150- to 1,150-Hz frequency band. At a later point, observers sighted belugas moving away from the source at >12.4 mi (> 20 km) with received levels of ~90 dB re 1 μPa rms in the 150- to 1,150-Hz band. The total number of animals observed fleeing was about 300, suggesting approximately 100 independent groups (of three individuals each). No whales were sighted the following day, but some were sighted on 30 June, with ship noise audible at spectrum levels of approximately 55 dB re 1 μPa rms/Hz (up to 4 kHz).

Observations during 1983 (LGL & Greeneridge 1986) involved two icebreaking ships with aerial survey and ice-based observations during seven sampling periods. Narwhals and belugas generally reacted at received levels ranging from 101 to 121 dB re 1 μPa rms in the 20- to 1,000-Hz band and at a distance of up to 65 km. Large numbers (100s) of beluga whales moved out of the area at higher received levels. As noise levels from icebreaking operations diminished, a total of 45 narwhals returned to the area and engaged in diving and foraging behavior. During the final sampling period, following an 8-hour quiet interval, no reactions were seen from 28 narwhals and 17 belugas (at received levels ranging up to 115 dB re 1 μPa rms).

The final season (1984) reported in LGL & Greeneridge (1986) involved aerial surveys before, during, and after the passage of two icebreaking ships. During operations, no belugas and few narwhals were observed in an area approximately 17 mi (27 km) ahead of the vessels, and all whales sighted over 12-50 mi (19 to 80 km) from the ships were swimming strongly away. Additional observations confirmed the spatial extent of avoidance reactions to this sound source in this context.

Gordon et al. (1992) conducted opportunistic visual and acoustic monitoring of sperm whales in New Zealand exposed to nearby whale-watching boats (within 1,476 ft./450 m). Sperm whales respired less frequently, had shorter surface intervals, and took longer to start clicking at the start of a dive descent when boats were nearby than when they were absent. Noise spectrum levels of whale watching boats ranged from 109 to 129 dB re 1 μPa rms/Hz. Over a bandwidth of 100 to 6,000 Hz, equivalent broadband source levels were ~157 dB re 1 μPa rms; received levels at a range of 1,476 ft. (450 m) were ~104 dB re 1 μPa rms.

Buckstaff (2004) reported elevated dolphin whistle rates with received levels (RLs) from oncoming vessels in the 110 to < 120 dB re 1 μPa rms. These hearing thresholds were apparently lower than those reported by a researcher listening with towed hydrophones.

Morisaka et al. (2005) compared whistles from three populations of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). One population was exposed to vessel noise with spectrum levels of ~85 dB re 1 μPa rms/Hz in the 1- to 22-kHz band (broadband received levels ~128 dB re 1 μPa rms) as opposed to ~65 dB re 1 μPa rms/Hz in the same band (broadband RL ~108 dB re 1 μPa rms) for the other two sites. Dolphin whistles in the noisier environment had lower fundamental frequencies and less frequency modulation, suggesting a shift in sound parameters as a result of increased ambient noise.

Morton and Symonds (2002) used census data on killer whales in British Columbia to evaluate avoidance of nonpulse acoustic harassment devices (AHD). Avoidance ranges were about 2.5 mi (4 km). Also, there was a dramatic reduction in the number of days “resident” killer whales were sighted during AHD-active periods compared to pre- and post-exposure periods and a nearby control site.

Monteiro-Neto et al. (2004) studied avoidance responses of tucuxi (*Sotalia fluviatilis*) to Dukane Netmark acoustic deterrent devices. In a total of 30 exposure trials, ~5 groups each demonstrated avoidance compared to 20 pinger off and 55 no-pinger control trials over two quadrats of about 0.2 mi^2 (0.5 km^2). Estimated exposure received levels were ~115 dB re 1 μPa rms.

Awbrey & Stewart (1983) played back semi-submersible drillship sounds (source level: 163 dB re 1 μPa rms) to belugas in Alaska. They reported avoidance reactions at 985 ft. and 4,921 ft. (300 m and 1,500 m) and approach by groups at a distance of 3,927 yd (3,500 m) with received levels ~110 to 145 dB re 1 μPa rms over these ranges assuming a 15 log R transmission loss. Similarly, Richardson et al. (1990) played back drilling platform sounds (source level: 163 dB re 1 μPa rms) to belugas in Alaska. They conducted aerial observations of eight individuals among ~100 spread over an area several hundred meters to several kilometers from the sound source and found no obvious reactions. Moderate changes in movement were noted for three groups swimming within 656 ft. (200 m) of the sound projector.

Finally, two papers deal with important issues related to changes in marine mammal vocal behavior as a function of variable background noise levels. Foote et al. (2004) found increases in the duration of killer whale calls over the period 1977 to 2003, during which time vessel traffic in Puget Sound, and particularly whale-watching boats around the animals, increased dramatically. Scheifele et al. (2005) demonstrated that belugas in the St. Lawrence River increased the levels of their vocalizations as a function of the background noise level (the "Lombard Effect").

Several researchers conducting laboratory experiments on hearing and the effects of nonpulse sounds on hearing in mid-frequency cetaceans have reported concurrent behavioral responses. Nachtigall et al. (2003) reported that noise exposures up to 179 dB re 1 μPa rms and 55-min duration affected the trained behaviors of a bottlenose dolphin participating in a TTS experiment. Finneran & Schlundt (2004) provided a detailed, comprehensive analysis of the behavioral responses of belugas and bottlenose dolphins to 1-s tones (received levels 160 to 202 dB re 1 μPa rms) in the context of TTS experiments. Romano et al. (2004) investigated the physiological responses of a bottlenose dolphin and a beluga exposed to these tonal exposures and demonstrated a decrease in blood cortisol levels during a series of exposures between 130 and 201 dB re 1 μPa rms. Collectively, the laboratory observations suggested the onset of behavioral response at higher received levels than did field studies. The differences were likely related to the very different conditions and contextual variables between untrained, free-ranging individuals vs. laboratory subjects that were rewarded with food for tolerating noise exposure.

Based upon the above information regarding toothed whale disturbance reactions, Shell anticipates that some toothed whales may exhibit minor, short-term disturbance responses to underwater sounds from drilling and associated support activities. Any potential impacts on toothed whale behavior would be localized within the activity area and would not result in population-level effects.

(c) Pinnipeds

Pinnipeds generally seem to be less responsive to exposure to industrial sound than most cetaceans. Pinniped responses to underwater sound from some types of industrial activities such as seismic exploration appear to be temporary and localized (Harris et al. 2001, Reiser et al. 2009b).

Blackwell et al. (2004) reported little or no reaction of ringed seals in response to pile-driving activities during construction of a man-made island in the Beaufort Sea. Ringed seals were observed swimming as close as 150 ft. (46 m) from the island and may have been habituated to the sounds which were likely audible at distances <1.9 mi (<3.0 km) underwater and 0.3 mi (0.5 km) in air. Moulton et al. (2005) reported that ringed seal densities on ice in the vicinity of a man-made island in the Beaufort Sea did not change materially before and after construction and drilling activities.

Southall et al. (2007) reviewed literature describing responses of pinnipeds to non-pulsed sound and reported that the limited data suggest exposures between ~90 and 140 dB re 1 μPa rms generally do not appear to induce strong behavioral responses in pinnipeds exposed to nonpulse sounds in water; no data exist regarding exposures at higher levels. It is important to note that among these studies of pinnipeds responding to nonpulse exposures in water, there are some apparent differences in responses between field and laboratory conditions. In contrast to the mid-frequency odontocetes, captive pinnipeds responded more strongly at lower levels than did animals in the field. Again, contextual issues are the likely cause of this difference.

Jacobs & Terhune (2002) observed harbor seal reactions to AHDs (source level in this study was 172 dB re: 1 μPa rms) deployed around aquaculture sites. Seals were generally unresponsive to sounds from the AHDs. During two specific events, individuals came within 43 and 44 m of active AHDs and failed to demonstrate any measurable behavioral response; estimated received levels based on the measures given were ~120 to 130 dB re 1 μPa rms.

Costa et al. (2003) measured received noise levels from an Acoustic Thermometry of Ocean Climate (ATOC) program sound source off northern California using acoustic data loggers placed on translocated elephant seals. Subjects were captured on land, transported to sea, instrumented with archival acoustic tags, and released such that their transit would lead them near an active ATOC source (at 3,081 ft. [939-m] depth; 75-Hz signal with 37.5- Hz bandwidth; 195 dB re 1 μPa rms max. source level, ramped up from 165 dB re 1 μPa rms over 20 min) on their return to a haulout site. Received exposure levels of the ATOC source for experimental subjects averaged 128 dB re 1 μPa rms (range 118 to 137) in the 60- to 90-Hz band. None of the instrumented animals terminated dives or radically altered behavior upon exposure, but some statistically significant changes in diving parameters were documented in nine individuals. Translocated northern elephant seals exposed to this particular nonpulse source began to demonstrate subtle behavioral changes at ~120 to 140 dB re 1 μPa rms exposure RLs.

Kastelein et al. (2006) exposed nine captive harbor seals in a ~80 x 100 ft. (~24 × 30 m) enclosure to nonpulse sounds used in underwater data communication systems (similar to acoustic modems). Test signals were frequency modulated tones, sweeps, and bands of noise with fundamental frequencies between 8 and 16 kHz; 128 to 130 [± 3] dB re 1 μPa rms source levels; 1- to 2-s duration (60-80 percent duty cycle); or 100 percent duty cycle. They recorded seal positions and the mean number of individual surfacing behaviors during control periods (no exposure), before exposure, and in 15-min experimental sessions (n = 7 exposures for each sound type). Seals generally swam away from each source at received levels of ~107 dB re 1 μPa rms, avoiding it by ~5 m, although they did not haul out of the water or change surfacing behavior. Seal reactions did not appear to wane over repeated exposure (i.e., there was no obvious habituation), and the colony of seals generally returned to baseline conditions following exposure. The seals were not reinforced with food for remaining in the sound field.

Based upon the above information regarding pinniped disturbance reactions, Shell anticipates that some pinnipeds may exhibit minor, short-term disturbance responses to underwater sounds from drilling and associated support activities. Any potential impacts on pinniped behavior would be localized within the activity area and would not result in population-level effects.

Potential Effects of Exposure to Underwater Sounds from Airguns

The potential effects of underwater sounds from airgun associated activities might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995a). It is unlikely that there would be any cases of temporary or especially permanent hearing impairment, or non-auditory physical effects.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. In general, pinnipeds, small odontocetes, and sea otters seem to be more tolerant of exposure to airgun pulses than are baleen whales. Based upon the above information regarding marine mammal tolerance to underwater sounds, Shell anticipates that some marine mammals exposed to low levels of underwater sounds from exploratory drilling and associated activity may show no response.

Masking

Masking effects of underwater sounds on marine mammal calls and other natural sounds are expected to be limited. Masking effects of pulsed sounds (even from larger arrays of airguns than proposed in this project) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), a more recent study reports that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). That has also been shown during recent work in the Gulf of Mexico (Tyack et al. 2003). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced in the presence of airgun pulses (Richardson et al. 1986; Greene et al. 1999; Blackwell et al. 2009a). Bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Blackwell et al. 2009a,b). Additionally, there is increasing evidence that, at times, there is enough reverberation between airgun pulses such that detection range of calls may be reduced. In contrast, Di Iorio and Clark (2009) found evidence of increased calling by blue whales during operations by a lower-energy seismic source, a sparker. Masking effects of seismic pulses are expected to be negligible given the low number of cetaceans expected to be exposed, the intermittent nature of seismic pulses and the fact that ringed seals (the most abundant species in the area) are not typically vocal during this period. Based upon the above information regarding the masking effects of underwater sounds produced from airguns on marine mammal calls and other natural sounds, Shell anticipates any such impacts to be minimal.

Disturbance Reactions

(a) Mysticetes

Baleen whale responses to pulsed sound have been studied more thoroughly than responses to continuous sound. Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns may react by deviating from their normal migration route. In the case of the migrating gray and bowhead whales, observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors. Baleen whale responses to pulsed sound however, may depend on the type of activity in which the whales are engaged. Some evidence suggests that feeding bowhead whales may be more tolerant of underwater sound than migrating bowhead whales (Miller et al. 2005; Lyons et al. 2009; Christie et al. 2010).

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 2.8 to 9.0 mi (4.5 to 14.5 km) from the source. For the much smaller airgun array to be used during the ZVSP survey, distance to received level at the 160 dB re 1 µPa rms range is estimated to be ~2.27 mi (3.65km). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 µPa rms. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 12-19 mi (20–30 km) from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 µPa rms (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 1999).

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in.^{3} (1,639 cm^3) airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 µPa rms on an (approximate) rms basis, and that 10 percent of feeding whales interrupted feeding at received levels of 163 dB re 1 µPa rms. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia during a seismic survey (Yazvenko et al. 2007).

Data on short-term reactions (or lack of reactions) of cetaceans to pulsed sounds do not necessarily provide information about long-term effects. It is not known whether pulsed sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Appendix A in Malme et al. 1984). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987). Populations of both gray whales and bowhead whales grew substantially during this time. In any event, the brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in prolonged effects.

Based upon the above information regarding baleen whale disturbance reactions, Shell anticipates that some baleen whales may exhibit minor, short-term disturbance responses to underwater sounds from airguns. Any potential impacts on baleen whale behavior would be localized within the activity area and would not result in population-level effects.

(b) Odontocetes

Few systematic data are available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack et al. 2003), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Moulton and Miller 2005).

Seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 6-12 mi (10–20 km) of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 6-12 mi (10–20 km) (Miller et al. 2005). Captive bottlenose dolphins and (of more relevance in this project) beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2002, 2005). However, the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 µPa rms) before exhibiting aversive behaviors.

Reactions of toothed whales to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for mysticetes. A ≥170 dB re 1 µPa rms disturbance criterion (rather than ≥160 dB re 1 µPa rms) is considered appropriate for delphinids (and pinnipeds), which tend to be less responsive than other cetaceans. However, based on the limited existing evidence, belugas should not be grouped with delphinids in the "less responsive" category.

Based upon the above information regarding toothed whale disturbance reactions, Shell anticipates that some toothed whales may exhibit minor, short-term disturbance responses to underwater sounds from airguns. Any potential impacts on toothed whale behavior would be localized within the activity area and would not result in population-level effects.

(c) Pinnipeds

Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources that will be used. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the species occurring in the present study area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations. As for delphinids, a ≥170 dB re 1 µPa rms disturbance criterion may be a more realistic threshold for pinnipeds, which tend to be less responsive than many cetaceans (Moulton and Lawson 2002, NMFS 2009), however the ≥160 dB re 1 µPa rms criterion is currently used as a conservative method to assess Level B thresholds for pinnipeds (NMFS 2012c).

Based upon the above information regarding pinniped disturbance reactions, Shell anticipates that some pinnipeds may exhibit minor, short-term disturbance responses to underwater sounds from airguns. Any potential impacts on pinniped behavior would be localized within the activity area and would not result in population-level effects.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to pulsed sounds 180 and ≥190 dB re 1 µPa rms, respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii during seismic survey activities in the Arctic in recent years. However, those criteria were established before there was data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals.

- the 180 dB re 1 µPa rms criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid TTS, let alone permanent auditory injury, at least for belugas and delphinids (NMFS 2013a).
- the minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- the level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage (NMFS 2013a).

The NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005; D. Wieting in Orenstein et al. 2004). New science-based noise exposure criteria are also proposed by a group of experts in this field, based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al., 2007) and this review seems to confirm that the current 180 dB re 1 μPa rms and 190 dB re 1 μPa rms are conservative.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the exploration drilling activities to avoid exposing them to underwater sound levels that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the proposed activities. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to industrial sound sources and beaked whales do not occur in the proposed study area. It is unlikely that any effects of these types would occur during the proposed project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures (see below). The following sections discuss in somewhat more detail the possibilities of TTS, Permanent Threshold Shift (PTS), and non-auditory physical effects.

(a) Temporary Threshold Shift

TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple impulses of sound. There are, however, recent data on TTS in dolphins caused by multiple pulses of sonar sound, Mooney et al. (2009).

The distinction between TTS and PTS is not absolute. Although mild TTS is fully reversible and is not considered to be injury, exposure to considerably higher levels of sound causes more “robust” TTS, involving a more pronounced temporary impairment of sensitivity that takes longer to recover. There are very few data on recovery of marine mammals from substantial degrees of TTS, but in terrestrial mammals there is evidence that “robust” TTS may not be fully recoverable, i.e., TTS can grade into PTS (Le Prell 2012).

The received energy level of a single seismic pulse that caused the onset of mild TTS in the beluga, as measured without frequency weighting, was ~186 dB re 1 $\mu Pa^2 \cdot s$ or 186 dB Sound Exposure Level (SEL) (Finneran et al. 2002).[2] The rms level of an airgun pulse (in dB re 1 μPa measured over the

[2] If the low-frequency components of the watergun sound used in the experiments of Finneran et al. (2002) are downweighted as recommended by Southall et al. (2007) using their M_{mf}-weighting curve, the effective exposure level for onset of mild TTS was 183 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al. 2007).

duration of the pulse) is typically 10–15 dB higher than the SEL for the same pulse when received within a few kilometers of the airguns. Thus, a single airgun pulse might need to have a received level of ~196–201 dB re 1 µPa rms in order to produce brief, mild TTS. Exposure to several strong seismic pulses that each has a flat-weighted received level near 190 dB re 1 µPa rms (175–180 dB SEL) could result in cumulative exposure of ~186 dB SEL (flat-weighted) or ~183 dB SEL (M_{mf}-weighted), and thus slight TTS in a small odontocete. That assumes that the TTS threshold upon exposure to multiple pulses is (to a first approximation) a function of the total received pulse energy, without allowance for any recovery between pulses.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. However, no cases of TTS are expected given the moderate size of the source, and the likelihood that baleen whales (especially migrating bowheads) would avoid the drilling and vessel activities before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures to sound suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001; cf. Au et al. 2000). For harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odontocetes.

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 µPa rms. New criteria are likely to include a time component in addition to sound pressure level which has been the only metric used previously when developing mitigation measures for industrial sound exposure for marine mammals. Due to the relatively small sound radii expected to result from the proposed exploration drilling and support activities, marine mammals would be unlikely to incur TTS without remaining very near the activities for some unknown time period. Given Shell's proposed mitigation and the likelihood that many marine mammals are likely to avoid the proposed activities, exposure sufficient to produce TTS is unlikely to occur (NMFS 2013a).

(b) Permanent Threshold Shift

When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges.

There is no specific evidence that exposure to underwater industrial sound associated with oil exploration can cause PTS in any marine mammal. However, given the possibility that mammals might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to such activities might incur PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause permanent hearing impairment during the proposed exploration drilling program (NMFS 2012c). Marine mammals are unlikely to be exposed to received levels strong enough to cause even slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the drilling units may not be sufficient to induce PTS, even if the animals remain in the immediate vicinity of the activity. Shell's planned monitoring and mitigation measures, including measurement of sound radii and visual monitoring when mammals are seen within "safety radii", will minimize the already-minimal probability of exposure of marine mammals to sounds strong enough to induce PTS.

(c) Non-auditory Physiological Effects

Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that material physiological stress would develop.

Until recently, it was assumed that diving marine mammals are not subject to the bends or air embolism. This possibility was first explored at a workshop (Gentry [ed.] 2002) held to discuss whether the stranding of beaked whales in the Bahamas in 2000 (Balcomb and Claridge 2001; NOAA and USN 2001) might have been related to bubble formation in tissues caused by exposure to noise from naval sonar. However, the opinions were inconclusive. Jepson et al. (2003) first suggested a possible link between mid-frequency sonar activity and acute and chronic tissue damage that results from the formation in vivo of gas bubbles, based on the beaked whale stranding in the Canary Islands in 2002 during naval exercises. Fernández et al. (2005a) showed those beaked whales did indeed have gas bubble-associated lesions as well as fat embolisms. Fernández et al. (2005b) also found evidence of fat embolism in three beaked whales that stranded 62 mi (100 km) north of the Canaries in 2004 during naval exercises. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (e.g., Arbelo et al. 2005; Jepson et al. 2005a; Méndez et al. 2005). Most of the afflicted species were deep divers. There is speculation that gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei (Potter 2004; Arbelo et al. 2005; Fernández et al. 2005a; Jepson et al. 2005b). Even if gas and fat embolisms can occur during exposure to mid-frequency sonar, there is no evidence that that type of effect occurs in response to the types of sound produced during the proposed exploration drilling activities, including the use of the airgun. Also, most evidence for such effects has been in beaked whales, which do not occur in the proposed survey area.

Summary of Hearing Impairment and Other Physical Effects

Available data on the potential for underwater sounds from industrial activities to cause auditory impairment or other physical effects in marine mammals suggest that such effects, if they occur at all, would be temporary and limited to short distances. Marine mammals that show behavioral avoidance of the proposed activities, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects.

Stranding and Mortality

Marine mammal stranding or mortality would be highly unlikely to result from any of the proposed exploration drilling or related support activities (NMFS 2011). Marine mammal strandings have been correlated with pulsed sounds produced during previous marine survey activities. Most of these events, however, involved beaked whales, which do not occur in the Chukchi Sea. Additionally, the pulsed sound produced from the proposed ZVSP activities will be at much lower levels than those reported during stranding events. Underwater sounds from drilling and support activities are less energetic and have slower rise times, and there is no evidence that they can cause serious injury, death, or stranding.

The most likely potential cause of mortality to marine mammals from the proposed activities would be a ship strike, and there have been no such strikes documented during oil and gas exploration activities in the Alaskan Arctic. Trained observers aboard project vessels are authorized to request mitigation measures, including reduction in vessel speed and course alteration, to minimize potential ship strikes. Given the above information, it is extremely unlikely that the proposed activities would result in stranding or mortality to marine mammals in the Chukchi Sea.

8. ANTICIPATED IMPACTS ON SUBSISTENCE USERS

Subsistence hunting continues to be an essential aspect of Inupiat Native life, especially in rural coastal villages. The Inupiat participate in subsistence hunting activities in and around the Chukchi Sea. The animals taken for subsistence provide a significant portion of the food that will last the community through the year. Marine mammals represent on the order of 60-80 percent of the total subsistence harvest. Along with the nourishment necessary for survival, the subsistence activities strengthen bonds within the culture, provide a means for educating the younger generation, provide supplies for artistic expression, and allow for important celebratory events. In this IHA application, Shell specifically discusses the potential impact from the exploration drilling program to subsistence use of the bowhead whale, beluga, and seals, which are the primary marine mammals harvested for subsistence that are also covered under this authorization of incidental take by NMFS.

The MMPA requires that any harassment not result in an unmitigable adverse impact on the availability of species or stocks for taking (101(a)(5)(D)(i)(II)). Unmitigable adverse impact is defined as (50 CFR 216.103):

An impact resulting from the specified activity that-

- is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by
  - causing marine mammals to abandon or avoid hunting areas;
  - directly displacing subsistence users; or,
  - placing physical barriers between the marine mammals and the subsistence users; AND
- cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

As described throughout this document, Shell's planned exploration drilling program may result in Level B harassment of marine mammal species or stocks. However, our analysis supports the conclusion that any harassment will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Bowhead Whale

Sound energy and general activity associated with drilling and operation of vessels and aircraft have the potential to temporarily affect the behavior of bowhead whales. As noted above in Section 7, monitoring studies (Davis 1987, Brewer et al. 1993, Hall et al. 1994) have documented temporary diversions in the swim path of migrating bowheads near drill sites; however, the whales have generally been observed to resume their initial migratory route within a distance of 6-20 mi (10-32 km). Drilling noise has not been shown to block or impede migration even in narrow ice leads (Davis 1987, Richardson et al. 1991).

Behavioral effects on bowhead whales from sound energy produced by drilling, such as avoidance, deflection, and changes in surface/dive ratios, have generally been found to be limited areas around the drill site that are ensonified to >160 dB re 1 μPa rms, although effects have infrequently been observed out as far as areas ensonified to 120 dB re 1 μPa rms. Ensonification by drilling to levels >120 dB re 1 μPa rms will be limited to areas within about 0.93 mi (1.5 km) of either drilling units during Shell's exploration drilling program (Table 6-3). Shell's proposed drill sites are located more than 64 mi (103 km) from the Chukchi Sea coastline, whereas mapping of subsistence use areas indicates bowhead hunts are conducted within about 30 mi (48 km) of shore; there is therefore little or no opportunity for the proposed exploration drilling activities to affect bowhead hunts.

Vessel traffic along planned travel corridors between the drill sites and marine support facilities in Barrow and Wainwright would traverse some areas used during bowhead harvests by Chukchi villages. Bowhead hunts by residents of Wainwright, Point Hope and Point Lay take place almost exclusively in the spring prior to the date on which Shell would commence the proposed exploration drilling program. From 1984 through 2009, all bowhead harvests by these Chukchi Sea villages occurred only between April 14 and June 24 (George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010), while Shell will not enter the Chukchi Sea prior to July 1. However, fall whaling by some of these Chukchi Sea villages has occurred since 2010 and is likely to occur in the future, particularly if bowhead quotas are not completely filled during the spring hunt, and fall weather is accommodating. A Wainwright whaling crew harvested the first fall bowhead for these villages in 90 years or more on October 7, 2010, and another in October of 2011 (Suydam et al. 2011, 2012, 2013). No bowhead whales were harvested during fall in 2012, but 3 were harvested by Wainwright in fall 2013.

Barrow crews have traditionally hunted bowheads during both spring and fall; however spring whaling by Barrow crews is normally finished before the date on which Shell operations would commence. From 1984 through 2011 whales were harvested in the spring by Barrow crews only between April 23 and June 15 (George and Tarpley 1986; George et al. 1987, 1988, 1990, 1992, 1995, 1998, 1999, 2000; Philo et al. 1994; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013). Fall whaling by Barrow crews does take place during the time period when vessels associated with Shell’s exploration drilling program would be in the Chukchi Sea. From 1984 through 2011, whales were harvested in the fall by Barrow crews between August 31 and October 30, indicating that there is potential for vessel traffic to affect these hunts. Most fall whaling by Barrow crews, however, takes place east of Barrow along the Beaufort Sea coast therefore providing little opportunity for vessel traffic associated with Shell’s exploration drilling program to affect them. For example, Suydam et al. (2008) reported that in the previous 35 years, Barrow whaling crews harvested almost all their whales in the Beaufort Sea to the east of Point Barrow. Shell's mitigation measures, which include a system of Subsistence Advisors (SAs), Community Liaisons, and Com Centers; will be implemented to avoid any effects from vessel traffic on fall whaling in the Chukchi Sea by Barrow and Wainwright.

Aircraft traffic (helicopters and small fixed wing airplanes) between the drill sites and facilities in Wainwright and Barrow would also traverse these subsistence areas. Flights between the drill sites and Wainwright or other shoreline locations would take place after the date on which spring bowhead whaling out of Point Hope, Point Lay, and Wainwright is typically finished for the year; however, Wainwright has harvested bowheads in the fall since 2010 and aircraft may traverse areas sometimes utilized for these fall hunts. Aircraft overflights between the drill sites and Barrow or other shoreline locations could also occur over areas used by Barrow crews during fall whaling, but again, most fall whaling by Barrow crews takes place to the east of Barrow in the Beaufort Sea. The most commonly observed reactions of bowheads to aircraft traffic are hasty dives, but changes in orientation, dispersal, and changes in activity are sometimes noted. Such reactions could potentially affect subsistence hunts if the flights occurred near and at the same time as the hunt, but Shell has developed and proposes to implement a number of mitigation measures to avoid such impacts. These mitigation measures include minimum flight altitudes, employment of SAs, and Com Centers as described below in Section 12. Twice-daily calls are held during the exploration drilling program and are attended by operations staff, logistics staff, and SAs. Vessel movements and aircraft flights are adjusted as needed and planned in a manner that avoids potential impacts to bowhead whale hunts and other subsistence activities. With these mitigation measures and the nature of our proposed action, we are confident that any harassment of bowhead whales resulting from the 2015 exploration drilling program will not have an unmitigable adverse impact on the availability of this stock to be taken for subsistence uses. .

Beluga Whale

Beluga whales typically do not represent a large proportion of the subsistence harvests by weight in the communities of Wainwright and Barrow, the nearest communities to Shell's planned exploration drilling program. Barrow residents hunt beluga in the spring (normally after the bowhead hunt) in leads between Point Barrow and Skull Cliffs in the Chukchi Sea, primarily in April-June and later in the summer (July-August) on both sides of the barrier island in Elson Lagoon/Beaufort Sea (Minerals Management Service [MMS] 2008), but harvest rates indicate the hunts are not frequent. Wainwright residents hunt beluga in April-June in the spring lead system, but this hunt typically occurs only if there are no bowheads in the area. Communal hunts for beluga are conducted along the coastal lagoon system later in July-August.

Belugas typically represent a much greater proportion of the subsistence harvest in Point Lay and Point Hope. Point Lay's primary beluga hunt occurs from mid-June through mid-July, but can sometimes continue into August if early success is not sufficient. Point Hope residents hunt beluga primarily in the lead system during the spring (late March to early June) bowhead hunt, but also in open water along the coastline in July and August. Belugas are harvested in coastal waters near these villages, generally within a few miles from shore. Shell's proposed drill sites are located more than 60 mi (97 km) offshore, therefore proposed exploration drilling in the Burger Prospect would have no or minimal impacts on beluga hunts. Aircraft and vessel traffic between the drill sites and support facilities in Wainwright, and aircraft traffic between the drill sites and air support facilities in Barrow would traverse areas that are sometimes used for subsistence hunting of belugas.

Disturbance associated with vessel and aircraft traffic could therefore potentially affect beluga hunts. However, all of the beluga hunt by Barrow residents in the Chukchi Sea, and much of the hunt by Wainwright residents would likely be completed before Shell activities would commence. Additionally, vessel and aircraft traffic associated with Shell's planned exploration drilling program will be restricted under normal conditions to designated corridors that remain onshore or proceed directly offshore thereby minimizing the amount of traffic in coastal waters where beluga hunts take place. The designated vessel and aircraft traffic corridors do not traverse areas indicated in recent mapping as utilized by Point Lay or Point Hope for beluga hunts, and avoids important beluga hunting areas in Kasegaluk Lagoon that are used by Wainwright. Shell has developed and proposes to implement a number of mitigation measures, e.g., PSOs on board vessels, minimum flight altitudes, and the SA and Com Center programs, to ensure that there is no impact on the availability of the beluga whale as a subsistence resource. .. With these mitigation measures and the nature of our proposed action, we are confident that any harassment of beluga whales resulting from the 2015 exploration drilling program will not have an unmitigable adverse impact on the availability of this stock to be taken for subsistence uses.

Pinnipeds

Seals are an important subsistence resource and ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling program would commence, but some harvest continues during open water and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer. Most seals are harvested in coastal waters, with available maps of recent and past subsistence use areas indicating seal harvests have occurred only within 30-40 mi (48-64 km) of the coastline. Shell's planned drill sites are located more than 64 statute mi (103 km) offshore, so activities within the Burger Prospect, such as drilling, would have no impact on subsistence hunting for seals. Helicopter traffic between land and the offshore exploration drilling operations could potentially disturb seals and, therefore, subsistence hunts for seals, but any such effects would be minor and temporary lasting only minutes after the flight has passed due to the small number of flights and the altitude at which they typically fly, and the fact that most seal hunting is done during the winter and spring when the exploration drilling program is not operational. Mitigation measures to be implemented by Shell include minimum flight altitudes, employment of subsistence advisors in the villages, and operation of Com Centers as described below in Section 12. With these mitigation measures and the nature of our proposed action, we are confident that any harassment of pinnipeds resulting from the 2015 exploration drilling program will not have an unmitigable adverse impact on the availability of this stock to be taken for subsistence uses.

9. ANTICIPATED IMPACTS ON HABITAT

Shell's planned exploration drilling program will not result in any permanent impact on habitats used by marine mammals, or to their prey sources.. The primary potential impacts to habitat expected are associated with elevated sound levels from exploration drilling operations, its support vessels, and aircraft that result in marine mammals avoiding the area. These effects on marine mammal habitat from the generation of underwater sound from the planned exploration drilling program are expected to be negligible and temporary, lasting only as long as the activity is on-going. A very small area of seafloor will be disturbed through the construction of MLCs, mooring of the drilling units, and discharge of drilling wastes. Benthic habitat would be altered in these areas, resulting in an indirect effect on benthic feeding marine mammals. All such effects would be negligible as only a very small portion of the available habitat would be affected and because the area would soon be re-colonized by benthic organisms.

This section identifies potential impacts to habitat, discusses the effect of each impact on marine mammals and threatened and endangered species, and then discusses the effect of the impact on primary food types, as applicable.

Potential Impacts on Habitat from Seafloor Disturbance (Mooring and MLC Construction)

Mooring of the drilling units and construction of MLCs will result in some seafloor disturbance and temporary increases in water column turbidity.

The drilling units would be held in place during operations with systems of eight anchors for each unit. The embedment type anchors designed to embed into the seafloor thereby providing the required resistance. The anchors will penetrate the seafloor on contact and may drag 2-3 or more times their length while being set. Both the anchor and anchor chain will disturb sediments in this process creating a trench or depression with surrounding berms where the displaced sediment is mounded. Some sediments will be suspended in the water column during the setting and subsequent removal of the anchors. The depression with associated berm, collectively known as an anchor scar, remains when the anchor is removed.

Dimensions of future anchor scars can be estimated based on the dimensions of the anchor. We estimate that each anchor may impact a seafloor area of up to about 2,510 ft^2 ($233m^2$). Minimum impact estimates associated with mooring the *Discoverer* at a well by its eight anchors is 18,267 ft^2 (1,697 m^2) of seafloor assuming that the anchors are set only once and 20,078 ft^2 (1,865 m^2) for the *Polar Pioneer*. Shell plans to pre-set anchors and deploy mooring lines at each drill site prior to arrival of the drilling units. Unless moved by an outside force such as sea current, anchors should only need to be set once per drill site.

Once the drilling units end operation, the *Polar Pioneer* anchors will be retrieved and the *Discoverer* anchors may be left on site for wet storage. Over time the anchor scars will be filled through natural movement of sediment. The duration of the scars depends upon the energy of the system, water depth, ice scour, and sediment type. Anchor scars were visible under low energy conditions in the North Sea for five to ten years after retrieval. Scars typically do not form or persist in sandy mud or sand sediments but may last for nine years in hard clays (Centaur Associates, Inc. 1984). Surficial sediments in Shell's Burger Prospect consist of soft sandy mud (silt and clay) with lesser amounts of gravel (Battelle Memorial Institute 2010; Blanchard et al. 2010a, b). The energy regime, plus possible effects of ice gouge in the Chukchi Sea suggests that anchor scars would be refilled faster than in the North Sea.

Excavation of each MLC by the drilling units using a large diameter drill bit will displace about 770 yd^3. ($589m^3$) of seafloor sediments and directly disturb approximately 1,075 ft^2 (100 m^2) of seafloor. Some of the excavated sediments will be displaced to adjacent seafloor areas and some will be pumped and discharged on the seafloor away from the MLC. These excavated materials will also have some indirect effects as they are suspended in the water and deposited on the seafloor in the vicinity of the MLCs.

Direct and indirect effects would include slight changes in seafloor relief and sediment consistency, and smothering of benthic organisms.

Potential Impacts on Habitat from Sound Generation

Marine Mammal Avoidance

This section focusses specifically on impacts to the habitat from sound generation that result in marine mammal avoidance. Additional impacts from sound are discussed in section 7 of the application. Shell does not expect any material or lasting impacts to the habitat from sound energy created by exploration drilling activities in the Chukchi Sea. Sound is crucial to marine mammals because they use it to navigate, communicate, find open water, avoid predators, and find food. There are a variety of sounds in the Chukchi Sea, especially during the "open water" drilling season, when the area is exposed to the peak level of man-made sound from oil and gas exploration activities and biological research surveys. Sound sources from Shell's exploration activities that could be heard by marine mammals include the drilling units, marine vessels, and support vessels. Sounds that are natural in the marine environment of the Chukchi Sea include sound from ice, surf, subsea landslides, and other animals. Concern has been expressed regarding the presence and intensity of impacts from sound energy that result in a deflection of whales from hunting and migration areas. Based on previous studies regarding sound energy and effects on marine mammals, as well as the preventive mitigation measures planned for the project, Shell does not expect any material or lasting impacts to marine mammals from sound energy resulting from exploration drilling activities in the Chukchi Sea.

Avoidance behavior in response to sound energy by marine mammals, such as temporary deflection, is the most likely behavioral response expected as a result of Shell's exploration drilling activities in the Chukchi Sea. Depending upon the sound source, different mitigation measures will be implemented. Mitigation measures have been included in the 4MP that is included as an appendix of this IHA application. That discussion and analysis of Shell's sound energy mitigation measures is incorporated here by reference.

PSOs will be stationed on the drilling units and primary and secondary ice management vessels and transiting support vessels to ensure all required marine mammal mitigation measures are implemented. All vessels should avoid concentrations or groups of whales to the maximum distance possible, and reduce speed to at least 5 knots if within 900 ft. (274 m) of whales. If a marine mammal is sighted from a moving vessel within a distance that requires mitigation, the Shell vessel will reduce speed or alter course. Full activity will not be resumed until all marine mammals are beyond distances that require mitigation. Regular overflight surveys and support vessel surveys for marine mammals will be conducted to further monitor drilling areas.

Anchored vessels, including the drilling units, or non-anchored vessels in DP will remain stationary and in DP and continue ongoing operations if approached by a marine mammal. The anchored units will remain in place and continue ongoing operations to avoid possibly causing avoidance behavior by suddenly changing sound conditions.

Shell will not be operating during periods of the year when the mammals may be more sensitive to disturbance such as during pupping and molting. These important activities will be over by the time Shell activities start. Seals hauled out on ice in the vicinity of operations may be temporarily displaced.

While observing the response of beluga whales to icebreakers, Finley and Davis (1984) reported avoidance behavior when icebreakers approached at distances of 22-31 mi (35-50 km). Belugas are thought to have poor hearing below one Hz, the range of most drilling activities, but have shown some behavioral reactions to the sounds. Brewer et al. (1993) observed belugas within 2.3 mi (3.7 km) of the drilling unit *Kulluk* during drilling.

At distances greater than 660-1,300 ft. (200-400 m), recorded sounds from drilling activities did not have biologically significant effects on beluga whales even though the sound energy level and frequency were such that it could be heard several kilometers away (Richardson et al. 1995b). This exposure did result in minor deflection from the sound energy and temporary changes in behavior. These changes are not expected to affect whale populations (Richardson et al. 1991; Richard et al. 1998).

Threatened and Endangered Species

Sound is important to bowhead whales because they use it to navigate, communicate, find open water, avoid predators, and find areas of food abundance. Bowhead whales, along with being endangered, are a key subsistence resource of the Inupiat Eskimos of the North Slope. There is concern regarding potential deflection of the whales due to sound energy produced by exploration drilling activities from harvest areas. There have been no conclusive studies on the sensitivity of bowhead whale hearing (Richardson et al. 1995b). It is likely that the range of hearing includes the frequency range used in their calls. Most frequencies used by bowhead whales are low (less than 1,000 Hz) (Richardson et al. 1995b). Mitigation measures are in place to minimize or eliminate impacts to the whales and, by extension, subsistence uses of the whales. Shell does not expect any lasting impacts on marine mammals from sound energy created during exploration drilling activities in the Chukchi Sea.

In order to limit the likelihood of disturbance of whales with ice management and other support vessels, at a minimum, PSOs will be stationed on the drilling units and primary and secondary ice management vessels, and transiting vessels to survey for marine mammals. Vessel movements will also avoid separation of whales within groups, slow down during periods of low visibility, and overall avoid having more than a negligible effect on subsistence. Regular overflight surveys for marine mammals will be conducted to further monitor drilling areas. Anchored vessels, including the drilling units, or vessels on DP will remain at anchor, or on DP, and continue ongoing operations if approached by a marine mammal. The anchored or DP vessels will remain in place and continue ongoing operations to avoid possibly causing avoidance behavior by suddenly changing sound energy conditions.

Avoidance behavior in response to sound by marine mammals such as temporary deflection from migration corridors is the most likely behavioral response expected as a result of Shell's exploration activities in the Chukchi Sea. Bowhead whales, likely due to their hearing range, have been reported to react more to low frequency sounds than higher frequency sounds (Richardson et al. 1995b). Davis (1987) studied the responses exhibited by bowhead whales to drilling sound. The only response he saw was avoidance behavior in some whales. Davis (1987) concluded that avoidance behavior was temporary and sound energy from drilling did not impede migration of the whales. Recordings from the drilling ship *Explorer II* were projected in the Canadian Beaufort Sea during the drilling season (Richardson et al. 1985a). Changes in behavior in response to the sounds were observed. Some whales showed avoidance behavior, but the deflection away from the sound was considered weak (Richardson et al. 1985a). During the same study, Richardson et al. (1985a) observed whales between 2.5 mi and 12.4 mi (4 and 20 km) while drilling activity was occurring, and he concluded that the whales were undisturbed. In a similar study where recordings from the drilling unit *Kulluk* were projected, no deflection was seen until sound pressure levels reached 120 dB re 1 μPa rms or higher (Wartzok et al. 1989).

Seals are not expected to avoid the area due to sound energy from Shell vessel traffic or exploration drilling. This was demonstrated during a study designed to assess ringed seals' reactions to drilling activity (Brewer et al. 1993). After observing the seals approach within 33 ft. (10 m) of the drilling unit *Kulluk*, the scientists concluded that they are not disturbed by drilling activity. The same conclusion was reached concerning bearded seals that approached within 656 ft. (200 m) of icebreakers (Brewer et al. 1993). In another study involving the drillship *Explorer II*, seals were observed within 115 ft. (35 m) of the ship during drilling (Gallagher et al. 1992).

Zooplankton

Zooplankton are not threatened or endangered under the ESA. They are, however, food sources for several endangered species, including bowhead, fin, and humpback whales. The primary generators of sound energy associated with the exploration drilling program are the airgun array during the conduct of ZVSPs, the drilling units during drilling, and marine vessels, particularly during ice management and DP. Sound energy generated by these activities will not negatively impact the diversity and abundance of zooplankton, and will therefore have no direct effect on marine mammals.

Sound energy generated by the airgun arrays to be used for the ZVSPs will have no more than negligible effects on zooplankton. Studies on euphausiids and copepods, which are some of the more abundant and biologically important groups of zooplankton in the Chukchi Sea, have documented the use of hearing receptors to maintain schooling structures (Wiese 1996) and detection of predators (Hartline et al. 1996, Wong 1996) respectively, and therefore have some sensitivity to sound; however any effects of airguns on zooplankton would be expected to be restricted to the area within a few feet or meters of the airgun array and would likely be sublethal. Studies on brown shrimp in the Wadden Sea (Webb and Kempf 1998) revealed no particular sensitivity to sounds generated by airguns used in with sound levels of 190 dB re 1 μPa rms at 3.3 ft. (1.0 m) in water depths of 6.6 ft. (2.0 m). Kosheleva (1992) reported no detectable effects on the amphipod (*Gammarus locusta*) at distances as close as 0.5 m from an airgun with a source level of 223 dB re 1 μPa rms. A recent Canadian government review of the impacts of seismic sound on invertebrates and other organisms (CDFO 2004) included similar findings; this review noted “there are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions” (CDFO 2004). Some sublethal effects (e.g., reduced growth, behavioral changes) were noted (CDFO 2004).

The energy from airguns has sometimes been shown to damage eggs and fry of some fish. Eggs and larvae of some fish may apparently sustain sublethal to lethal effects if they are within very close proximity to the seismic-energy-discharge point. These types of effects have been demonstrated by some laboratory experiments using single airguns (e.g., Kosheleva 1992, Matishov 1992, Holliday et al. 1987), while other similar studies have found no material increases in mortality or morbidity due to airgun exposure (Dalen and Knutsen 1986, Kostyuvchenko 1973). The effects, where they do occur, are apparently limited to the area within 3-6 ft. (1-2 m) from the airgun-discharge ports. In their detailed review of studies on the effects of airguns on fish and fisheries, Dalen et al. (1996) concluded that airguns can have deleterious effects on fish eggs and larvae out to a distance of 16 ft. (5.0 m), but that the most frequent and serious injuries are restricted to the area within 5.0 ft. (1.5 m) of the airguns. Most investigators and reviewers (Gausland 2003, Thomson and Davis 2001, Dalen et al. 1996) have concluded that even seismic surveys with much larger airgun arrays than are used for shallow hazards and site clearance surveys, have no impact to fish eggs and larvae discernible at the population or fisheries level.

These studies indicate that some zooplankton within a distance of about 16 ft. (5.0 m) or less from the airgun array may sustain sublethal or lethal injuries but there would be no population effects even over small areas. Therefore there would be no indirect effect on marine mammals.

Ice management vessels are likely to be the most intense sources of sound associated with the exploration drilling program Richardson et al. (1995a). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drilling units maintain station during drilling without activation of propulsion propellers. Richardson et al. (1995a) reported that the noise generated by an icebreaker pushing ice was 10-15 dB re 1 μPa rms greater than the noise produced by the ship underway in open water. It is expected that the lower level of sound produced by the drilling units, ice management, or other vessels would have less impact on zooplankton than would 3D seismic (survey) sound.

No appreciable adverse impact on zooplankton populations will occur due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortality or impacts on zooplankton as a result of Shell's operations is immaterial as compared to the naturally-occurring reproductive and mortality rates of these species. This is consistent with previous conclusions that crustaceans (such as zooplankton) are not particularly sensitive to sound produced by seismic sounds (Wiese 1996). Impact from sound energy generated by an ice breaker, other marine vessels, and drill ships would have less impact, as these activities produce lower sound energy levels (Burns et al. 1993). Historical sound propagation studies performed on the *Kulluk* by Hall et al. (1994) also indicate the *Kulluk* and similar drilling units would have lower sound energy output than three-dimensional seismic sound sources (Burns et al. 1993). The drilling units *Discoverer* and *Polar Pioneer* would emit sounds at a lower level than the *Kulluk* and therefore the impacts due to drilling noise would be even lower than the *Kulluk*. Therefore, zooplankton organisms would not likely be affected by sound energy levels by the vessels to be used during Shell's exploration drilling activities in the Chukchi Sea.

Benthos

There was no indication from benthic biomass or density that previous drilling activities at the Hammerhead Prospect have had a measurable impact on the ecology of the immediate local area. To the contrary, the abundance of benthic communities in the Sivulliq area would suggest that the benthos were actually thriving there (Dunton et al. 2008).

Sound energy generated by exploration drilling and ice management activities will not appreciably affect diversity and abundance of plants or animals on the seafloor. The primary generators of sound energy are the drilling units and marine vessels. Ice management vessels are likely to be the loudest sources of sounds associated with the exploration drilling program (Richardson et al. 1995a). Ice management vessels, during active ice management, may have to adjust course forward and astern while moving ice and thereby create greater variability in propeller cavitation than other vessels that maintain course with less adjustment. The drilling units maintain station during drilling without activation of propulsion propellers. Richardson et al. (1995a) reported that the noise generated by an icebreaker pushing ice was 10-15 dB re 1 µPa rms greater than the noise produced by the ship underway in open water. The lower level of sound produced by the drilling units, ice management vessels, or other vessels will have less impact on bottom-dwelling organisms than would 3D seismic (survey) sound.

No appreciable adverse impacts on benthic populations would be expected due in part to large reproductive capacities and naturally high levels of predation and mortality of these populations. Any mortalities or impacts that might occur as a result of Shell's operations is immaterial compared to the naturally occurring high reproductive and mortality rates. This is consistent with previous BOEM conclusions that the effect of seismic exploration on benthic organisms probably would be immeasurable (USDI/MMS 2007). Impacts from sound energy generated by ice breakers, other marine vessels, and drilling units would have less impact, as these activities produce much lower sound energy levels (Burns et al. 1993).

Fish

Fish react to sound and use sound to communicate (Tavolga et al. 1981). Experiments have shown that fish can sense both the intensity and direction of sound (Hawkins 1981). Whether or not fish can hear a particular sound depends upon its frequency and intensity. Wavelength and the natural background sound also play a role. The intensity of sound in water decreases with distance as a result of geometrical spreading and absorption. Therefore, the distance between the sound source and the fish is important. Physical conditions in the sea, such as temperature thermoclines and seabed topography, can influence transmission loss and thus the distance at which a sound can be heard.

The impact of sound energy from exploration drilling and ice management activities will be negligible and temporary. Fish typically move away from sound energy above a level that is at 120 dB re 1 µPa rms or higher (Ona 1988).

Drilling unit sound source levels during drilling can range from 90 dB re 1 µPa rms within 31 mi (50 km) of the drilling unit to 138 dB re 1 µPa rms within a distance of 0.06 mi (0.01 km) from the drilling unit (Greene 1985, 1987b). These are predicted sound levels at various distances based on modeled transmission loss equations in the literature (Greene 1987b). Ice management vessel sound source levels can range from 174-184 dB re 1 µPa rms. At these intensity levels, fish may avoid the drilling unit, ice management vessels, or other large support vessels. This avoidance behavior is temporary and limited to periods when a vessel is underway or drilling.

There have been no studies of the direct effects of ice management vessel sounds on fish. However, it is known that the ice management vessels produce sounds generally 10-15 dB re 1 µPa rms higher when moving through ice rather than open water (Richardson et al. 1995b). In general, fish show greater reactions to a spike in sound energy levels, or impulse sounds, rather than a continuous high intensity signal (Blaxter et al. 1981).

Fish sensitivity to impulse sound such as that generated by ZVSPs varies depending on the species of fish. Cod, herring and other species of fish with swim bladders have been found to be relatively sensitive to sound, while mackerel, flatfish, and many other species that lack swim bladders have been found to have poor hearing (Hawkins 1981, Hastings and Popper 2005). An alarm response in these fish is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level (Blaxter et al. 1981). A recent study of feeding herring schools off of Northern Norway demonstrated no reaction to an approach by an active seismic vessel. (Pena et al. 2013). Any such effects on fish would be minimal and would not be expected to diminish a marine mammal species' or stocks' foraging success. .

Potential Impacts on Habitat from Drilling Wastes

Shell will discharge drilling wastes to the Chukchi Sea. These discharges will be authorized under the EPA's NPDES exploration facilitites GP for Oil and Gas Exploration Activities on the Outer Continental Shelf in the Chukchi Sea (AKG-28-8100; NPDES exploration facilities GP). This permit establishes various limits and conditions on the authorized discharges, and the EPA has determined that with these limits and conditions the discharges will not result in any unreasonable degradation of ocean waters.

Under the NPDES exploration facilities GP, drilling wastes to be discharged must have a 96-hr Lethal Concentration 50 percent (LC_{50}) toxicity of 30,000 parts per million or greater at the point of discharge. Both modeling and field studies have shown that discharged drilling wastes are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b, Brandsma et al. 1980, NRC 1983, O'Reilly et al. 1989, Nedwed et al. 2004, Smith et al. 2004; Neff 2005). The dilution is strongly affected by the discharge rate. The NPDES exploration facilities GP limits the discharge of drilling wastes to 1,000 bbl./hr. (159 m^3/hr.). For example, TetraTech (2011) modeled hypothetical 1,000 bbl./hr. (159 m^3/hr.) discharges of drilling wastes in water depths of 131-164 ft. (40-50 m) in the Beaufort and Chukchi Seas for the EPA and predicted dilution factors of 950-17,500 at a distance of 330 ft. (100 m) from the discharge point.

The primary effect of the drilling waste discharges will be increases in total suspended solids (TSS) in the water column and localized increase in sedimentation on the sea floor. Shell conducted dispersion modeling of the drilling waste discharges using the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model (Fluid Dynamix 2014 a,b). Simulations were performed for each of the six discrete drilling intervals with two discharge locations: seafloor and sea surface. The Burger Prospect wells are all very similar in well design and site conditions so the simulation approximates the results for the all drill sites. The model results indicate that most of the increase in TSS will be ameliorated within 984 ft. (300 m) of the discharge locations through settling and dispersion. Impacts to water quality will cease when the discharge is concluded.

Modeling of similar discharges offshore of Sakhalin Island predicted a 1,000-fold dilution within 10 minutes and 330 ft. (100 m) of the discharge. In a field study (O'Reilly et al. 1989) of a drilling waste discharge offshore of California, a 270 bbl. (43 m^3) discharge of drilling wastes was found to be diluted 183-fold at 33 ft. (10 m) and 1,049-fold at 330 ft. (100 m). Neff (2005) concluded that concentrations of discharged drilling waste to levels that would have no effect within about two minutes of discharge and within 16 ft. (5 m) of the discharge location.

Marine Mammals

Discharges of drilling wastes must be authorized by the NPDES exploration facilities GP, and this GP places numerous conditions and limitations on such discharges. The EPA (2012a) has determined that with these limits and conditions in place, the discharges will not result in any unreasonable degradation of ocean waters. The primary impacts of the discharges are increases in TSS in the water column and the deposition of drilling wastes on the seafloor. These impacts would be localized to the drill sites and temporary.

Discharges of drilling wastes could potentially displace marine mammals a short distance from a drilling location. However, it is likely that marine mammals will have already avoided the area due to sound energy generated by the drilling activities. Gray whales will more than likely avoid drilling activities and therefore not come into close contact with drilling wastes. Gray whales are benthic feeders and the seafloor area covered by accumulations of discharged drilling wastes will be unavailable to the whales for foraging purposes, and represents an indirect impact on these animals. Such indirect impacts are negligible resulting in little effect on individual whales and no effect on the population, because such areas of disturbance will be few and in total will occur over a very small area representing an extremely small portion of available foraging habitat in the Chukchi Sea. Other baleen whales such as the minke whale, which could be found near the drill site, would not be expected to be affected.

Discharges of drilling wastes are not likely to affect beluga whales and other odontocetes such as harbor porpoises and killer whales. These marine mammals will likely avoid the immediate areas where drilling wastes will be discharged. Discharge modeling performed for both the *Discoverer* and the *Polar Pioneer* based on maximum prevailing current speeds of 9.84 in/s (25 cm/s), shows that sedimentation depth of drilling wastes at greater than 0.4 in (1 cm) thickness will occur within approximately 1,641 (500 m) of the drilling unit discharge point (Fluid Dynamix, 2014 a, b). Concentrations of TSS, a transient feature of the discharge, are modeled to be below 15 mg/L at distances approximately 3,281 ft. (1,000 m) from the drilling unit discharge point. Therefore, it is highly unlikely that beluga whales will come into contact with any drilling discharge and impacts are not expected.

Spotted seals are also not expected to be impacted by the discharges of drilling wastes. It is highly unlikely that a seal would remain within 330 ft. (100 m) of the discharge source for any extended period of time but if they were to remain within 330 ft. (100 m) of the discharge source for an extended period of time, it is possible that physiological effects due to toxins could impact the animal.

Threatened and Endangered Species

Negative effects on endangered whales from drilling waste discharges are not expected. Baleen whales, such as bowheads, tend to avoid drilling units at distances up to 12 mi (20 km). Therefore, it is highly unlikely that the whales will swim or feed in close enough proximity of discharges to be affected.

The levels of drilling waste discharges are regulated by the NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Drilling waste discharges could displace endangered whales (bowhead and humpback whales) a short distance from a drill site. Effects on the whales present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, endangered whales are not likely to have long-term exposures to drilling wastes because of the episodic nature of discharges (typically only a few hours in duration).

Seals, including the threatened ringed seals and bearded seals whose recent listing as threatened was vacated and remanded back to NMFS, are not expected to be impacted by drilling wastes. If seals remain within 330 ft. (100 m) of the discharge source for an extended period of time, it is possible that physiological effects due to toxins could impact the animal. However, it is highly unlikely that a seal would remain within 330 ft. (100 m) of the discharge source for any extended period of time.

Zooplankton

Reviews by EPA (2006) and Neff (2005) indicate that though planktonic organisms are sensitive to environmental conditions (e.g., temperature, light, availability of nutrients, and water quality), there is little or no evidence of effects from drilling waste discharges on plankton in the ocean. In the laboratory, high concentrations of drilling wastes have been shown to have lethal or sublethal effects on zooplankton due to toxicity and abrasion by suspended sediments. These effects are minimized at the drill site by limits and conditions placed on the discharges by the NPDES exploration facilities GP, which include discharge rate limits and toxicity limits.

Any impact by drilling waste discharges on zooplankton would be localized and temporary. Fine-grained particulates and other solids in drilling wastes could cause sublethal effects to organisms in the water column. Responses observed in the laboratory following exposure to drilling mud include alteration of respiration and filtration rates and altered behavior. Zooplankton in the immediate area of discharge from drilling operations could potentially be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures, cause abrasions to gills and other sensitive tissues, or alter behavior or development. However, the planktonic organisms are not likely to have long-term exposures to the drilling waste because of the episodic nature of discharges (typically only a few hours in duration), the small area affected, and the movement of the organisms with the ocean currents. The discharged waste must have low toxicities to meet permit requirements and modeling studies indicate dilution factors of >1,000 within 328 ft. (100 m). Modeling and monitoring studies have demonstrated that increased TSS in the water column from the discharges would largely be limited to the area within 984 ft. (300 m) from the discharge. This impact would likely not have more than a short-term impact on zooplankton and no effect on zooplankton populations, and therefore no indirect effects on marine mammals.

Benthos

Benthic organisms would primarily be affected by the discharges through the deposition of the discharged drilling waste on the seafloor resulting in the smothering of organisms, changes in the consistency of sediments on the seafloor, and possible elevation in heavy metal concentrations in the accumulations.

Drilling waste discharges are regulated by the EPA's NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Effects on benthic organisms present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, benthic animals are not likely to have long-term exposures to drilling wastes because of the episodic nature of discharges (typically only a few hours in duration).

Shell conducted dispersion modeling of the drilling waste discharges using the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model (Fluid Dynamix 2014, a,b). The modeling effort provided predictions of the area and thickness of accumulations of discharged drilling waste on the seafloor. The USA EPA has performed an evaluation of drilling waste in support of the issuance of NPDES GP AKG-28-8100 for exploration facilities (EPA, 2012b), and determined these accumulation will not result in any unreasonable degradation of the marine environment.

Heavy metal contamination of sediments and resulting effects on benthic organisms is not expected. The NPDES exploration facilities GP contains stringent limitations on the concentrations of mercury, cadmium, chromium, silver, and thallium allowed in discharged drilling waste. Additional limitations are placed on free oil, diesel oil, and total aromatic hydrocarbons allowed in discharged drilling waste.

Discharge rates are also controlled by the permit. Baseline studies at the 1985 Hammerhead drill site (Trefry and Trocine 2009) detected background levels Al, Fe, Zn, Cd and Hg in all surface and subsurface sediment samples. Considering the relatively small area that drilling waste discharges will be deposited, no material impacts on sediment are expected to occur. The expected increased concentrations of Zn, Cd, and Cr in sediments near the drill site due to the discharge are in the range where no or low effects would result.

Studies in the 1980s, 1999, 2000, and 2002 (Brown et al. 2001 in USDI/MMS 2003) also found that benthic organism near drill sites in the Beaufort Sea have accumulated neither petroleum hydrocarbon nor heavy metals. In 2008 Shell investigated the benthic communities (Dunton et al. 2008) and sediments (Trefry and Trocine 2009) around the Sivulliq Prospect including the location of the historical Hammerhead drill site that was drilled in 1985. Benthic communities at the historical Hammerhead drill site were found not to differ statistically in abundance, community structure, or diversity, from benthic communities elsewhere in this portion of the Beaufort Sea, indicating that there was no long term effect.

Sediment samples taken in the CSESP Burger Study Area were analyzed for metal and hydrocarbon concentrations (Neff et al. 2010). Concentrations of all measured hydrocarbon types were found to be well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies (Neff et al. 2010, Dunton et al. 2012). Metal concentrations were found to be quite variable. Average concentrations of all metals except for arsenic and barium were found to be lower than those reported for average marine sediment.

Trefry et al. (2012) confirmed findings by Neff et al. 2010 that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

Neff et al. (2010) assessed the concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells in the Chukchi Sea, which were drilled in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2-3 times greater at the historic drill sites (mean = 1,410 µ/g and 1,300 µ/g) than in the surrounding areas (639 µ/g and 595 µ/g). Concentrations of copper, mercury, and lead, were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (below ERL or Effects Range Low of Long et al. 1995) believed to have adverse ecological effects (Neff et al. 2010). Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea.

These data show that the potential accumulation of heavy metals in discharged drilling waste on the Chukchi seafloor associated with drilling exploration wells is very limited and does not pose a threat. Impacts to seafloor sediments from the discharge of drilling wastes will be minor, as they would be restricted to a very small portion of the activity area and will not result in contamination.

The drilling waste discharges will be conducted as authorized by the EPA’s NPDES exploration facilities GP, which limits the metal content and flow rate for such discharges. The EPA (2012b) analyzed the effects of these types of discharges, including potential transport of pollutants such as metals by biological, physical, or chemical processes, and has concluded that these types of discharges do not result in unreasonable degradation of ocean waters. The physical effects of mooring and MLC construction would be restricted to a very small portion of the Chukchi Sea seafloor (15.7-33.2 ac in total for the exploration program) which represents less than 0.000011% - 0.000024% of the seafloor of the Chukchi Sea. However, the predicted small increases in concentrations of metals will likely be evident for a number of years until gouged by ice, redistributed by currents, or buried under natural sedimentation.

There is relatively little information on the effects of various deposition depths on arctic biota (Hurley and Ellis 2004); most such studies have investigated the effects of deposition of dredged materials (Wilber 1992). Burial depths as low as 1.0 in (2.54 cm) have been found to be lethal for some benthic organisms (Wilber 1992, EPA 2006). Accumulations of drilling waste to depths > 1.0 in (>2.54 cm) will be restricted to very small areas of the seafloor around each drill site and in total represent an extremely small portion of the Chukchi Sea. These areas would be re-colonized by benthic organisms rather quickly. Impacts to benthic organisms are therefore considered to be negligible with no indirect effects on marine mammals. As required by the NPDES exploration facilities GP, Shell will implement an environmental monitoring program (EMP), to assess the recovery of the benthos from impacts drilling waste discharges.

Fish

Drilling waste discharges are regulated by the NPDES exploration facilities GP. The impact of drilling waste discharges would be localized and temporary. Drilling waste discharges could displace fish a short distance from a drill site. Effects on fish and fish larvae present within a few meters of the discharge point would be expected, primarily due to sedimentation. However, fish and fish larvae that live in the water column are not likely to have long-term exposures to drilling wastes because of the episodic nature of the discharges (typically only a few hours in duration).

Although unlikely at deeper offshore drilling locations, demersal fish eggs could be smothered if discharges occur in a spawning area during the period of egg production. No specific demersal fish spawning locations have been identified at the Burger drill site locations. The most abundant and trophically important marine fish, the Arctic cod, spawns with planktonic eggs and larvae under the sea ice during winter and will therefore have little exposure to discharges.

Habitat alteration concerns apply to special or relatively uncommon habitats, such as those important for spawning, nursery, or overwintering. Important fish overwintering habitats are located in coastal rivers and nearshore coastal waters, but are not found in the proposed exploration drilling areas. Important spawning areas have not been identified in the Chukchi Sea. Any such effects on fish would be minimal and would not be expected to diminish a marine mammal species' or stocks' foraging success.

Potential Impacts on Habitat from Ice Management

Ice management activities include the physical pushing or moving of ice in the proposed exploration drilling area and to prevent ice floes from striking the drilling unit. Ringed, bearded, and spotted seals (along with the ribbon seal and walrus) are dependent on sea ice for at least part of their life history. Sea ice is important for life functions such as resting, breeding, and molting. These species are dependent on two different types of ice: pack ice and landfast ice. Shell does not expect to have to manage pack ice during the majority of the drilling season. The majority of the ice management should occur in the early and latter portions of the drilling season. Landfast ice would not be present during Shell's proposed operations.

The ringed seal is the most common pinniped species in the Chukchi Sea activity area. While ringed seals use ice year-round, they do not construct lairs for pupping until late winter/early spring on the landfast ice. As Shell's proposed drilling operations are not expected to begin until on or after 1 July and end on or prior to 31 October, our activities should not impact ringed seal lairs or habitat needed for breeding and pupping in the Chukchi Sea. Ringed seals can be found on the pack ice surface in the late spring and early summer in the Chukchi Sea, the latter part of which may overlap with the start of Shell's planned exploration drilling activities. Management of pack ice that contains hauled out seals may result in the animals becoming startled and entering the water, but such effects would be brief and we will implement measures to ensure the least practicable impact on the species.

Ice management would occur during a time when ringed seal life functions such as breeding, pupping, and molting do not occur in the proposed project area. Additionally, these life functions occur more commonly on landfast ice, which will not be impacted by Shell's activity.

Bearded seals breed in the Bering and Chukchi Seas, but would not be plentiful in the area of the Chukchi Sea exploration drilling program. Spotted seals are even less common in the Chukchi Sea activity area. Ice is used by bearded and spotted seals for critical life functions such as breeding and molting, but it is unlikely these life functions would occur in the proposed project area, during the time in which drilling activities will take place. The availability of ice would not be impacted as a result of Shell's exploration drilling program.

Ice-management related to Shell's planned exploration drilling program in the Chukchi Sea is not expected to have any habitat-related effects that could cause material or long-term consequences for individual marine mammals or on the food sources that they utilize.

Potential Impacts on Habitat from Drilling Units' Presence

The length of the *Discoverer* at 514 ft. (156.7 m) and *Polar Pioneer* at 279 ft. (85m) are not large enough to cause large-scale diversions from the animals' normal swim and migratory paths. The drilling units' physical footprints are small relative to the size of the geographic region either would occupy, and will likely not cause marine mammals to deflect greatly from their typical migratory routes.

Any deflection of bowhead whales or other marine mammal species due to the physical presence of the drilling units or support vessels would be extremely small. Even if animals may deflect because of the presence of the drilling units, the Chukchi Sea's migratory corridor is much larger in size than the length of the drilling units, and animals would have other means of passage around the drilling units. In sum, the physical presence of the drilling units is not likely to cause a material deflection to migrating marine mammals. Moreover, any impacts would last only as long as the drilling units are actually present.

10. ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS

The effects of the planned exploration drilling program on habitat are expected to be minor. It is estimated that only a small portion of the animals utilizing the areas of the planned program would be temporarily displaced. During the period of the exploration drilling program most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Chukchi Sea typically occurs in September and October. Again, some bowheads might be temporarily displaced around the drilling operation during this time. The numbers of whales and seals subject to displacement, if any, would be extremely few in relation to abundance estimates for the mammals addressed under this IHA.

In addition, feeding does not appear to be an important activity by bowheads migrating through the Chukchi Sea in most years. In the absence of important feeding areas, the potential diversion of a small number of bowheads is not expected to have any long-term consequences for individual bowheads or their population. Bowheads, gray, or beluga whales are not predicted to be excluded from any habitat, nor are any seals predicted to be excluded from any habitat by the offshore exploration drilling program.

The planned exploration drilling program is not expected to have any habitat-related effects that would produce long-term effects to marine mammals or their habitat due to the limited extent of the acquisition areas and timing of the program.

11. MITIGATION MEASURES

Details regarding planned mitigations are discussed in Shell's 4MP (Attachment B).

12. ARCTIC SUBSISTENCE PLAN OF COOPERATION

NMFS regulations require a plan to include four elements, which are discussed below.

A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation

Shell has prepared and will implement a POC pursuant to BOEM Lease Sale Stipulation No. 5, which requires that all exploration operations be conducted in a manner that prevents unreasonable conflicts between oil and gas activities and the subsistence activities and resources of residents of the North Slope. This stipulation also requires adherence to USFWS and NMFS regulations, which require an operator to implement a POC to mitigate the potential for conflicts between the proposed activity and traditional subsistence activities (50 CFR § 18.124(c)(4) and 50 CFR § 216.104(a)(12)). A POC was prepared and submitted with the initial Chukchi Sea EP that was submitted to BOEM in May 2009, and approved on 7 December 2009. Subsequent POC Addendums were submitted in May 2011 with a revised Chukchi Sea EP and the IHA application for the 2012 exploration drilling program. For this IHA application, Shell has again updated the POC Addendum. The updated POC Addendum (see Attachment C) changes very little from 2012. The POC Addendum has been updated to include documentation of meetings undertaken to specifically gather feedback from stakeholder communities on our implementation of the Chukchi Sea exploration drilling program during 2012, plus inform and obtain their input regarding the continuation of the program with the addition of a second drilling unit, additional vessels and aircraft.

The POC Addendum identifies the measures that Shell has developed in consultation with North Slope subsistence communities to minimize any adverse effects on the availability of marine mammals for subsistence uses and will implement during its planned Chukchi Sea exploration drilling program planned to continue in the summer of 2015. In addition, the POC Addendum details Shell's communications and consultations with local subsistence communities concerning its planned exploration drilling program, potential conflicts with subsistence activities, and means of resolving any such conflicts (50 CFR § 18.128(d) and 50 CFR § 216.104(a) (12) (i), (ii), (iv)). Shell has documented its contacts with the North Slope subsistence communities, as well as the substance of its communications with subsistence stakeholder groups.

The leases within the Burger Prospect were acquired during the Chukchi Sea Oil and Gas Lease Sales 193 held in February 2008. During 2015 Shell plans to drill at up to four exploration drill sites within the Burger Prospect (Table 2-1).

Shell's Chukchi Sea exploration drilling program continues to include the Burger Prospect in the Chukchi Sea (Figure 1-1). This program was set out in detail in a revised Chukchi Sea EP submitted to BOEM in August 2014 and the impacts of the project, as well as the measures Shell will implement to mitigate those impacts, will be analyzed in the environmental assessment prepared by BOEM for the revised EP Also, a prior environmental assessment was completed by BOEM for the 2011 revised EP (BOEM 2011) that included mitigation measures that are already incorporated into the 2015 program. Shell will implement this POC Addendum, and the mitigation measures set-forth herein, for 2015 exploration drilling.

A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation

The POC Addendum report (Attachment C) provides a list of public meetings attended by Shell since 2012 to develop the POC and the POC Addendum. The POC Addendum is updated through July 2015, and includes sign-in sheets and presentation materials used at the POC meetings held in 2014 to present the 2015 Chukchi Sea exploration drilling information. Comment analysis tables for numerous meetings held during 2014 summarize feedback from the communities on Shell's 2015 exploration drilling and planned activities beginning in the summer of 2015. These comments analysis tables, with responses from Shell and corresponding mitigation measures pertinent to the comments are included in Attachment C.

A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing

The following mitigation measures, plans and programs, are integral to this POC and were developed during consultation with potentially affected subsistence groups and communities. These measures, plans, and programs to monitor and mitigate potential impacts to subsistence users and resources will be implemented by Shell during its exploration drilling operations in the Chukchi Sea. The mitigation measures Shell has adopted and will implement during its Chukchi Sea exploration drilling operations are listed and discussed below. These mitigation measures reflect Shell's experience conducting exploration activities in the Alaska Arctic OCS since the 1980s and its ongoing efforts to engage with local subsistence communities to better understand their concerns and develop appropriate and effective mitigation measures to address those concerns. This most recent version of Shell's planned mitigation measures was presented to community leaders and subsistence user groups starting in January 2009 and has evolved since in response to information learned during the consultation process.

To minimize any cultural or resource impacts from its exploration operations, Shell will continue to implement the following additional measures to ensure coordination of its activities with local subsistence users to minimize further the risk of impacting marine mammals and interfering with the subsistence hunt:

Communications

- Shell has developed a Communication Plan and will implement this plan before initiating exploration drilling operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Com Centers to be located in coastal villages along the Chukchi Sea during Shell's proposed exploration drilling activities.
- Shell will employ local SAs from the Chukchi Sea villages that are potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities. There will be one per village, working approximately 8-hr per day and 40-hr per week during each drilling season. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and provide advice on ways to minimize and mitigate potential negative impacts to subsistence resources during each drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; coordinating with the Com and Call Center personnel; and advising how to avoid subsistence conflicts.

Aircraft Travel

- Aircraft over land or sea shall not operate below 1,500 ft. (457 m) altitude unless engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation.
- Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft. (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers.

Vessel Travel

- The drilling unit(s) and support vessels will enter the Chukchi Sea through the Bering Strait on or after 1 July, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- The transit route for the drilling unit(s) and drilling support fleets will avoid known fragile ecosystems and the Ledyard Bay Critical Habitat Unit (LBCHU), and will include coordination through Com Centers.
- PSOs will be aboard the drilling unit(s) and transiting support vessels.
- When within 900 ft. (274 m) of whales, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

ZVSP

- Airgun arrays will be ramped up slowly during ZVSPs to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB re 1 μPa rms for pinnipeds. The entire safety zone must be visible during the 30-min lead-in.to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.

Ice Management

- Real time ice and weather forecasting will be from SIWAC

Oil Spill Response

- Pre-booming is required for all fuel transfers between vessels

What plans does the applicant have to continue to meet with the affected communities prior to and while conducting the activity, to resolve conflicts and notify the communities of any changes in the operation

The potentially affected subsistence communities, identified in BOEM Lease Sale Stipulation No. 5, that were consulted regarding Shell's exploration drilling activities include: Barrow, Wainwright, Point Lay Point Hope, Kotzebue, and Deering. Additionally, Shell has met with subsistence groups including the Alaska Eskimo Whaling Commission (AEWC), Inupiat Community of the Arctic Slope (ICAS), and the Native Village of Barrow, and presented information regarding the proposed activities to the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB) Assemblies, and NSB and NWAB Planning Commissions during 2014. In July 2014, Shell conducted POC meetings in Chukchi villages to present information on the proposed 2015 drilling season. Shell has supplemented the IHA application with a POC addendum to incorporate these POC visits. Throughout 2014 and 2015 Shell anticipates continued engagement with the marine mammal commissions and committees active in the subsistence harvests and marine mammal research.

Shell continues to meet each year with the commissioners and committee heads of Alaska Beluga Whale Committee, the Nanuuq Commission, Eskimo Walrus Commission, and Ice Seal Committee jointly in co-management meetings. Shell held individual consultation meetings with representatives from the various marine mammal commissions to discuss the planned Chukchi exploration drilling program. Following the drilling season, Shell will have a post-season co-management meeting with the commissioners and committee heads to discuss results of mitigation measures and outcomes of the preceding season. The goal of the post-season meeting is to build upon the knowledge base, discuss successful or unsuccessful outcomes of mitigation measures, and possibly refine plans or mitigation measures if necessary.

Shell attended the 2012-2014 Conflict Avoidance Agreement (CAA) negotiation meetings in support of exploration drilling, offshore surveys, and future drilling plans. Shell will do the same for the upcoming 2015 exploration drilling program. Shell is committed to a CAA process and will demonstrate this by making a good-faith effort to negotiate an agreement every year it has planned activities.

13. MONITORING AND REPORTING

The planned marine mammal monitoring and mitigation program (4MP) for the Chukchi Sea exploration drilling program is included as Attachment B.

14. SUGGESTED MEANS OF COORDINATION

Various agencies and programs may undertake marine mammal studies in the Chukchi Sea during the course of the drilling season. It is unclear if these studies will be relevant to Shell's planned exploration drilling program. Shell is prepared to share information obtained during implementation of our marine mammal monitoring and mitigation program with a variety of groups who may find the data useful in their research. A suggested list of recipients includes:

- The NSB Department of Wildlife Management (T. Hepa)
- The USFWS Office of Marine Mammal Management (C. Perham, C. Putnam, and J. MacCracken)
- The BOEM's Aerial Surveys of Arctic Marine Mammals (ASAMM) (J. Denton)
- National Oceanic and Atmospheric Administration, National Marine Mammal Laboratory (Robyn Angliss)
- The Kuukpik Subsistence Oversight Panel (KSOP)
- Alaska Eskimo Whaling Commission (G.Noongwook -Savoonga)
- Alaska Beluga Whale Committee (W. Goodwin -Kotzebue)
- Ice Seal Committee (J. Goodwin – Kotzebue)
- Inupiat Community of the Arctic Slope (D. Lampe -Barrow)
- North Slope Science Initiative (J. Payne)
- Alaska Department of Natural Resources (S. Longan)
- Alaska Department of Fish and Game

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Attachment A
Drilling Ice Management Plan

Attachment B
Marine Mammal Monitoring and Mitigation Plan (4MP)

Attachment C
Plan of Cooperation (POC) Addendum